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EDITED BY J. MCKEEN CATTELL

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THE SCIENTIFIC MONTHLY

AUGUST, 1937

CONTRIBUTIONS OF THE MELLON INSTITUTE TO THE ADVANCEMENT OF SCIENCE[1]

A NATIONAL ASSET

By Dr. KARL T. COMPTON
PRESIDENT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

IT is a natural law, supported by both logic and experience, that it is the useful which survives. It is to their fundamental social value that such institutions as family, church, university, business and government have existed from time immemorial, each supplying an essential ingredient of that complex compound of mankind in the aggregate that we call society. Though changing in form to meet changing conditions and styles of living, these institutions continue to perform the essential functions respectively of reproduction, spiritual satisfaction, education, distribution and regulation.

It is important to note the ever-changing form and performance of these institutions, even though their basic function remains unaltered. The family in the days of Abraham, Isaac and Jacob was differently organized and faced different problems than the typical Pittsburgh family of 1937. Governmental authority has been variously vested—through personal physical prowess or conquest or heredity or purchase or demagogic persuasion or election by the people. Business has developed from the days of barter and hand labor to the present era of monetary transactions, mass production and high pressure distribution. Universities have changed vastly in their curricula and methods of instruction, but they are still devoted to the three original objectives: disciplined intellect, professional skill and new knowledge.

Our attention on this auspicious occasion is naturally directed toward two of these basic institutions, the university and business, since the Mellon Institute is derived from both and serves the public through both. I suppose that it would be proper to designate the Mellon family as the father of this institute, its parenthood made possible by success in business. Likewise the institute's mother is the University of Pittsburgh, within which it has developed and been reared to take its prominent place as an active member of that important group of institutions which perform essential national service in education and research.

A number of influences converge at the present time to enhance the value of the Mellon Institute and other institutions which perform similar functions, and of these influences I would speak briefly as follows.

In the first place, the Mellon Institute

[1] Based upon addresses presented at the time of the dedication of the new building of the Mellon Institute of Industrial Research in May.

is a scientific institution, and science is at the very root of our national program of objectives which our President has phrased as "the more abundant life." True, we do not see science advertised as an objective in political party platforms or even in the President's own messages to the Congress or to his friends, the people. It is even likely that few of those who are urging the various measures for improving the social and physical aspects of the nation have any real understanding of the fundamental rôle that science must play if these measures are to be successful. Yet this rôle exists, as the following analysis shows.

Prominent among our avowed national objectives are: the banishment of disease; elimination of unemployment; higher standard of living, including higher wages, shorter hours and greater opportunities for comfort and recreation; abolition of child labor; educational opportunities for all; social security against economic hazards or distress in old age; protection against natural hazards of flood, drought, wind, fire and earthquake; new markets for agricultural products.

I make bold to assert, for I believe that it can easily be proved, that there is not one of these fine objectives but that is basically dependent on science for its achievement. Take, for example, higher wages and shorter hours. Real wages are composed, of course, of all the things which a worker gets in return for his labor. In the last analysis the total wages which can be paid consist simply in the total number of necessary and desirable things which are produced in the world. Every new and useful product developed by science adds just so much to the sum total of real wages, and every machine for increasing production makes possible either more wages or shorter hours of labor or both.

It is a pity that so many of our social and political reformers have not evolved much beyond the "cave man" stage in their thinking. From the days of the cave man, all through history up to the modern era of science, there were only two primitive recipes for achieving the "more abundant life." One was to work hard and long in order to produce more; the other was to take the good things of life from some one else—by conquest or theft or taxation or exploitation. Too much of the doctrine of the more abundant life, even in our day, is based on the latter one of these primitive philosophies. To work hard and long to improve our lot has gone out of style; now the slogan is to soak the rich and to demand more while giving less.

Over against such primitive, though still popular, methods of seeking the good things of life, there is the sharp contrast of the modern method of putting science to work for us. If, by a practical application of science, men are enabled to produce with tenfold rapidity, it is evident that they can get along on their former standard of requirements, by working only one tenth as long as they had previously done. Or, if they want to work half as much as they did before, they will still produce five times as much as before, so that the average man's real wage will consist of the products of five times as much labor as he used to enjoy.

This is the basic philosophy of science as a means toward social betterment. Science creates new materials, new methods and new opportunities. There is real danger that, in the present activity of labor to demand more wages and of government to demand more taxes to support its altruistic aims, the demands may exceed the supply. In other words, demands for wages and taxes may exceed the capacity of industry and agriculture to produce. The only hope in such a situation is for science still further to add to man's ability to produce desirable things. In fact, had it not been for the past achievements of science, our wages and standards of living would still be, for the masses of the people, at the primitive levels of constant struggle against starvation and suffering.

Let me give a very up-to-date example of the social values of science. It is an old story, of course, that the automobile industry has provided enormous employment at about the highest wages of any large industry in history, and that the automobile has opened up new opportunities of living, recreation and achievement to millions of people. Here, however, is a more recent aspect. The number of automobiles sold in the past year in America was approximately equal to the number sold in the last boom year of 1929. By all measures, the new car is at least 50 per cent. better than that of 1929—in economy of operation, safety, comfort and general quality. Yet I am informed that the aggregate cost to the public of the present cars was $700,000,000 less than in 1929. So Mr. Citizen has a much better car and has saved $700,000,000, which he can spend for something else that he wants, such as a better home, more delicious food, travel, books, life insurance, clothes or a thousand and one things which altogether signify the "more abundant life."

The state of civilization of a people has been defined by the degree to which they are willing to sacrifice present pleasures for the sake of future benefits. If we all were really highly civilized and intelligent, we would see some striking contrasts to our present situation. We would see labor unions demanding the introduction by all industries of labor-saving and rapid production machinery in order that they might achieve higher wages and shorter hours. We would see the political forces of the country even more insistent in demanding the creation of new wealth than its distribution. In times of economic stress we would see the government strengthening its scientific services instead of curtailing them most severely of all services. We would see the agricultural problem tackled by a powerful scientific attempt to discover new uses for agricultural products rather than trying to achieve prosperity by curtailing production. We might even see income taxes which would encourage, rather than suppress, the man who creates a great and useful industry and who uses his wealth in a far-sighted manner for the public good.

Unfortunately our state of civilization, as a group, still falls far short of any such Utopia of intelligence. But fortunately there are some individuals who have vision, understanding and altruistic spirit who have also the ability and initiative of leadership, and who therefore supply those essential elements of progress which are lacking in the body politic. It is to such men that the world has always owed its slow but steady rise from barbarism to its present state of semi-civilization and improved standards of living. It is to such men that the world owes this Mellon Institute, which has already contributed so notably to our national welfare and which is to-night signalizing a new era of even greater accomplishment.

Since we all understand in a general way the functions of the Mellon Institute, and since there are many here more competent than I to discuss its operations in detail, I will confine my comments simply to a statement of its basic significance.

I have already spoken at length of the basic rôle of science in any program for social progress. Science's rôle extends all the way from the first observations of the facts of nature, through experiment and theory and still more experiment, past the formulation of proven principles, on through the practical applications of these forces and materials of nature for the benefit of mankind. These operations of science on a significant scale are fostered primarily by two of the institutions whose stable and essential character I remarked in the beginning—the universities and business. For it is in the universities, to a far greater extent than anywhere else, that the basic facts of science are discovered and studied, and

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it is there that the scientists themselves are trained. And it is business enterprise which organizes for the efficient production of the materials produced by science or which uses these materials for the performance of such essential functions as transportation, communication and other public services. Many progressive business organizations have built up great scientific organizations of their own, to conduct research and development of their own products.

The Mellon Institute fits strategically into this scheme, midway between the university and industry. In it the scientific discoveries made in the universities may be examined and developed with reference to their possible industrial value; in it the technical troubles of industry may be cured and its ambitions for new and better products or methods satisfied by the aid of science. It serves also as a training ground and recruiting center for applied scientists who will later be absorbed into industrial organizations. It provides the facilities of a research laboratory to the thousands of industrial units which have not as yet been able to justify the establishment of research laboratories of their own. In many cases, it demonstrates to an industry the advantage of creating its own permanent laboratory, as, for example, in the case of the now great research organization of the Gulf Oil Company, which originated in a research project at the Mellon Institute.

In the light of all these facts, facts of experience and facts of the present situation, and in a time when a crying need of the country is for the development of new industries, new uses for farm products, new forms of wealth that people will work and pay to possess, I can think of no better designation of this great institute, in which university and business unite to serve the nation through science, than to say that it is a "national asset." The Mellon Institute is performing a function which the government is not and probably should not be performing. But this function is so important that this institute and all other institutions which are similarly contributing to improve the general standard of living in basic ways through science should be encouraged and aided in every possible way by favorable legislation and private philanthropy.

As a representative of a sister institution which follows the same ideals, I offer congratulations and best wishes to the University of Pittsburgh and to its Mellon Institute at this celebration of its increased effectiveness, and I would express to the Mellon family my sincere conviction that their generosity has been well conceived in the public interest.

RECENT PROGRESS IN SYNTHETIC ORGANIC CHEMISTRY

By Dr. G. O. CURME, JR.
VICE-PRESIDENT, CARBIDE AND CARBON CHEMICALS CORPORATION

I HAVE always thought of the Mellon Institute as one of the spots in the world where new scientific discoveries are most sought for and best appreciated. Accordingly, it seems quite appropriate that this discussion of recent progress in science should be held here, where the accomplishments of scientists from all countries are constantly under review. I doubt if I can add any wholly new scientific facts of particular moment to the store already available. Valuable discoveries, when they become definitely established as representing progress, are always well known. The really new ideas that will be acclaimed in years to come are now being worked upon by those who have faith in them but are obscured by the great mass of accumulated scientific knowledge. I hope, however, that a re-

view of the significant accomplishments in that robust field of chemistry and industry, synthetic organic chemistry, may lead to a clearer understanding of its potentialities and thus enable still further progress to be made.

I have had for many years a deep personal interest in the general field of research which is represented on our program to-day by Dr. Banting. His activities and those of his colleagues are far removed from those with which I have been directly concerned, but I am sure that all scientists have a keen appreciation of the brilliant research and significant results which have come from the investigations on glandular extracts and vitamins. I have also taken some professional pride in the fact that these marvelous regulators of body functions, when isolated, have been found to be pure organic chemical substances and that an increasing number of them have been synthesized by purely chemical methods. As this joint field of medicine and chemistry has developed, there has occurred to me the similarity between the behavior of these synthesizable organic chemicals in regulating the animal economy and the behavior of the synthetic organic chemicals of industry in regulating many phases of our industrial economy. This comparison, of course, is somewhat fanciful and like all similes can not be carried too far. It is true, however, that synthetic organic chemicals have found and are finding valuable uses in almost all types of industrial operations and in general, although consumed in relatively small quantities, produce an effect out of proportion to the quantities involved.

A study of synthetic organic chemistry from this standpoint is somewhat at variance with the concepts of scientific research as established in earlier days in our universities. At one time generally and in many instances still there has been the thought that with millions of possible chemical compounds yet to be synthesized and described, the obvious duty of an organic chemist is to make and describe more and yet more new compounds. This is still a laudable purpose, and science should not be satisfied until all possible forms of matter have been catalogued and described. Concurrent with this effort, however, there is an obvious need for other scientific research which shall investigate the interaction of known compounds with other materials, so as to find out what unpredictable properties or potentialities may exist in new combinations. In biochemical and medical research a principal effort is made to study the effects of a particular substance or combination of substances on the human body and from such investigations the remarkable biochemical accomplishments of recent years have come. In my opinion, the greatest recent progress in synthetic organic chemistry also has come from a study of the application of previously known materials to practical uses along the general lines laid down by Dr. Duncan and since developed to a high degree at the Mellon Institute.

As is invariably the case when an effort is made to establish a definite beginning of a particular movement, it is found that there is always a prior event that deserves consideration. Certain syntheses of organic products certainly were made long before Wöhler's classic synthesis of urea, such as those of ethylene dichloride and of mercury fulminate. However, I am quite content to consider Sir William Perkin as the first scientist to conduct an organic synthesis purposefully and apply it in an intentionally useful manner on an industrial scale. Establishing such a date is of importance only in showing that all synthetic organic chemistry has been developed within the last eighty years and thus deserves to be considered fairly recent. The development of organic materials of predetermined characteristics to fill definite needs in industry is much more recent and has been employed on a wide scale only in recent years.

Whenever a new field of activity is opened up, new developments starting

from a focal point expand in all directions on an ever-increasing front. Furthermore, as the sum of accomplishment becomes greater, the relative increase resulting from any one discovery becomes smaller. In my opinion the time has passed in the synthetic organic chemical field when a revolutionary discovery, such as Schönbein's nitrocellulose or Perkin's mauvein, can be expected that will dwarf all preceding discoveries by comparison. This is not because many major discoveries are not at this time in the making, but rather because the progress already made is too substantial. The spectacular days of pioneering in a wholly new field are passing, but the important task of applying the valuable contributions of synthetic chemistry to our industrial and economic problems is just getting under way.

Since the time of Perkin, these materials, which on superficial inspection seem most unimpressive, have set up some rather striking records of performance in open competition with all other available materials. It has been shown that organic chemicals other than those which are physiologically active have the property of manifesting themselves in high dilution. As examples of somewhat unusual laboratory tests, I might mention the dyestuff, fluorescein, which gives distinct visual evidence of its presence when diluted with 40 million parts of water. Also the chemical, phenyl isocyanide, is recognizable by its odor in a greater dilution than that in which sodium is recognized by the sensitive spectroscopic flame test. These facts might well be classified as merely "stunts," interesting only to other organic chemists, and the inquiry made as to what could be done outside the laboratory. So, in the steel industry, which is far from the organic chemical laboratory, the acetylene flame cuts or joins metal shapes with enormously greater speed than any other means, and by the use of quantities insignificant compared with the tonnage of steel. In other cases where it is desired to strike the hardest possible blow, as in mining operations or in demolition work, the gaseous decomposition products from the detonation of synthetic organic chemicals, such as glycerol trinitrate or trinitro toluol, are employed. This has long been standard practice, and while taken as a matter of course to-day, it is still rather surprising to think that a pile driver, a stream of water from a nozzle and a gallon of nitroglycerine are capable of delivering an effective blow in the order mentioned. These performances, while more striking to the general public and constituting evidence that synthetic organic chemicals are not mere laboratory toys, were developed originally fairly early in the history of organic synthesis and are not fully representative of the ability of small quantities of a key material to motivate a whole industry.

A better example of this constituted a major field of research at the Mellon Institute twenty years ago in its investigation of frothing and collecting agents in the flotation process of concentrating ores. This type of operation, which has since found large-scale success, consumes a most minute amount of organic material, frequently of synthetic origin, but by its spectacular performance permits mining operations to be conducted profitably that otherwise could not be supported, and affects all the metal-consuming industries of the country in lowering costs and expanding ore reserves. Another similar case is the field of photography, never considered an organic chemical operation by most people. Yet without the sensitizers, developers and the plastic film, modern photography could not exist. The motion picture industry occupies a prominent position in our modern life and gives profitable employment to large numbers of people as well as education and enjoyment to still larger numbers. As such, it is an excellent example of a modicum of synthetic organic chemicals, animating a large human activity, which makes the active principle involved seem insignifi-

cant by comparison. These illustrations are not overdrawn cases, prepared for the purpose of glorifying the organic chemist. They are characteristic of the applications of these relatively new chemical products, where the original research on the material has been followed by even greater effort in studying its application.

In the short time at my disposal I can not go into an enumeration of the many parallel industries which have been either created *in toto* or brought to a wholly new degree of effectiveness by the studied interweaving of synthetic organic chemicals with other products and forces to produce an economically important result. National defense against human aggressors as well as sanitary defense against microorganisms in their modern form depend largely on synthetic organic chemicals as key products. The modern automobile and airplane, the outstanding accomplishments of the twentieth century to date, would be far from their present standard of excellence without the regulating effect of the synthetic products used in their construction and operation. Anti-knock fuels, special lubricants, durable tires and other rubber goods, anti-freeze materials, lacquer coatings, safety glass, brake fluids, plastic products, among other features, have permitted the remarkable degree of perfection and low cost which these unique products of our generation have attained.

It has been observed that those industries which are judged progressive by accepted standards are large consumers of synthetic organic chemicals and that those similarly judged as backward are among those whose consumption of these products is restricted. Such a statement is, of course, only relative, but it is most assuredly true that modern technology counts heavily on the tools supplied by synthetic organic chemistry and that the older technology, created before synthetic products became available, is rapidly being superseded. With the shining example of the more successful industries being heralded throughout the industrial world, the possibilities of modern technology are being adopted as rapidly as conditions will permit by other industries which have been less successful in their competition for the customer's dollar. Although such a movement is not particularly spectacular and must require a long time for completion, it seems to me one of the most important trends of the present time.

Our home construction industry has received much criticism during recent years, and on the basis of value received for cost and effort, it must be conceded that this criticism is largely deserved. That such a subject has reached the stage of public discussion, however, indicates that improvement has already begun. Our homes may not seem to us a chemical project, but in the countless applications of plastic materials, lacquers and synthetic fibers we may confidently expect new types of assembly to emerge with greatly reduced costs, while giving sanitary, noiseless, fireproof, moistureproof and verminproof construction, in keeping with known possibilities.

These plastics, in their scientific and technical development, as well as in their application to home construction and other industrial uses, constitute one of the major fronts on which synthetic organic chemistry is advancing to-day. In conception they are as old as the pitch and sun-dried bricks with which Noah and his predecessors were familiar. In their scientific understanding they are so new that not one of our universities offers an adequate course of study, preparing students either for engineering application or research on plastic materials. Such scientific study as these materials are receiving is being carried out in the research laboratories of a few industrial concerns, and the excellent results now being obtained are a tribute to the possibilities inherent in this class of materials. Many industries other than construction are benefiting by the use of plastics. Decorations and trimmings of plastics are very common to-day. Pack-

aging of foodstuffs has benefited from this use, as in the case of canned beer, which was made possible by a thin coating of a moisture-proof plastic material inside of the tin coating. Sound reproduction records, electrical insulation, parts for telephone and radio receivers and transmitters are among the growing list of uses for these materials. Extensible plastics or "synthetic rubbers" are also included in the list, which are rapidly leaving the experimental stage and becoming practical realities.

The rapid growth of cellulose acetate rayon has brought the stimulus of new possibilities to the textile industry, which welcomed synthetic dyestuffs eighty years ago. Other spinnable materials are now being experimented with which promise wholly new properties in textiles. New lubricants, sizing and other textile chemicals are under investigation, all of which should eventually assist in permitting improved textile products at lower costs. Among these textile chemicals, new synthetic materials lending special properties to aqueous solutions are of importance. Detergents and wetting agents which excel in certain respects the performance of soaps have been developed and put on the market recently. These are still in an experimental stage, and their eventual field of major usefulness remains to be determined. However, they serve at present to show the reawakening of interest in modern technology by the textile industry.

It has long been popular to lament the backwardness of our rail transportation units. The growing fleets of streamlined trains provide an appropriate reply that this important service industry is already undergoing a revision to increase its effectiveness. Since the Diesel motor unit is in reality of greater significance than the more obvious streamlined exterior, there is reason to expect that modernization of rail transportation will follow generally the trends of automotive engineering. In such event there is a certainty that synthetic organic chemicals will serve their part well, although the general public may notice them only indirectly, through the passing of former inconveniences.

Agriculture has always been most conservative and as an industry based on photosynthesis of organic products has, in a sense, been competitive with industrial organic synthesis. Perhaps a compensating benefit of the trying times of the past several years has been the arousing of mutual interest between these two groups. For some years the farmer has been a buyer of special synthetic organic chemicals for farm use in the form of insecticides, seed disinfectants, fumigants, sterilizing solutions, weed killers and the like in addition to those purchased indirectly through household and automotive products. In return the chemical manufacturers have been large purchasers of agricultural products such as cotton, animal and vegetable oils, naval stores, starch and sugar, in addition to food and other farm products consumed by chemical workers. It is rather common to find in the chemical industry that among one's largest customers are other chemical manufacturers. Once it is generally realized that the agriculturist is essentially a producer of volume goods and the synthetic organic chemical manufacturer essentially a producer of specialties, tailored to meet rigid specifications, the few cases where competition exists should be overshadowed by the many cases where a mutually profitable exchange of goods can occur. Much public discussion of this subject has taken place recently and beneficial results should follow. It would be an exception to the past successes of the chemical industry, however, if the degradation of foodstuffs to a motor fuel, requiring a subsidy from our already overburdened taxpayers to offset the economic loss involved, were the best form of cooperation between chemists and farmers to be found.

This has been called an age of speciali-

zation and it has even been threatened that as our specialists learn more and more about less and less they will eventually approach the condition of knowing absolutely everything about nothing at all. If such a minute subdivision of our technical knowledge, or anything remotely resembling it, were ever to come about as a real condition, it would indeed be a serious situation. However, I firmly believe that there is less serious danger of dangerous excesses being indulged in by our scientific and technical specialists than by any other social group. The tendency toward ultra-specialization undoubtedly does exist to-day, but along with it other coordinating tendencies also exist. These offset the potential harm which might come from uncoordinated knowledge, while permitting the advantages which come from detailed study of individual fields. Among these coordinating tendencies, I consider that the interweaving of synthetic organic chemistry into almost all fields of experimental science is an important one. I have no false illusions about synthetic organic chemistry being the dominant science, for no science can be more than a relatively small part of our whole body of scientific knowledge. I do believe, however, that when synthetic organic chemistry is studied in its applications as well as in its origins of materials, it is peculiarly well adapted to bind together and harmonize the other branches of science and industry into a more effective and practical whole.

THE PROBLEM OF CHEMO-THERAPY IN PNEUMONIA

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In 1911 Morganroth, in Germany, noted that the quinine derivative, ethylhydrocupreine or optochin, had strong power to destroy the pneumococcus. Naturally, clinical investigations were made with this chemical in order to demonstrate its possible value in the treatment of the human disease caused by the pneumococcus (pneumonia). However, it was soon evident that this preparation had a most serious defect; namely, it produced blindness if given in a dosage adequate to be effective in human pneumonia. Smaller doses could be given with comparative safety as far as blindness was concerned, but the anti-pneumococcic power was consequently so diminished as to make the drug of little value in the severe or potentially fatal cases of this infection. The blindness was usually not permanent and was not present in all individuals, even if they took equal amounts of the chemical; but the loss of vision, if only temporary, was still a very serious complication and it made the use of ethylhydrocupreine in clinical medicine practically impossible. In 1930 Miura and co-workers, in Japan, brought out ethylapocupreine. They stated that it was more powerful and less toxic than ethylhydrocupreine. Gundel and Seitz, in Germany, and our group in Pittsburgh at the Mellon Institute in 1933–34 confirmed the studies of the Japanese workers. Unfortunately, this chemical, like optochin, also produced blindness and therefore could not be placed among the useful drugs of medicine.

For several years Dr. L. H. Cretcher, of the Mellon Institute, and I had discussed the possibility of chemotherapy in pneumonia, and sometime during the winter of 1930 we decided that the attempt should be made to produce a quinine salt which had power to destroy or inhibit the growth of the pneumococcus

while at the same time to be free from the damaging effects on the vision of the patient.

The number of chemical preparations that have now been studied is 76. After each quinine derivative had been prepared by the chemists it was then tested by us in the following way; the effect on the growth of pneumococci in the test-tube was established; the ability of the chemical to protect white mice from death after they had been injected intraperitoneally with virulent pneumococci and an accurate quantitative measurement of the toxic dose for white mice of known weight was estimated. It was found that some preparations had considerable bactericidal power but were very toxic and were accordingly discarded. The opposite was also true, as a very slight toxicity was of no advantage if the preparation had lost its anti-pneumococcic power. In all the protection and toxicity experiments optochin and ethylapocupreine were used as controls, and the minimum unit of mice for each dose was 30, hence it is not surprising that the number of white mice used in this study is now about 20,000. The toxicity experiments in mice, however, do not give one any information regarding the most important factor that is seen in man when taking optochin, ethylapocupreine or occasionally even quinine itself, namely, visual disturbance. The rabbit appears to be immune to these eye lesions, and therefore, another species of animal had to be found for experimental study. In association with Professor W. T. Dawson we were able to get most valuable and essential information in regard to blindness by the use of a small number of dogs. This animal reacts in the same way as does the human as far as the eye is concerned. This experimental work was carried out by Dawson in the department of pharmacology at the University of Texas, and the subsequent microscopic examination of the eyes was done here. The eye lesion produced by certain quinine derivatives in the dog is pathologically a degeneration of the inner ganglionic layer of cells of the retina, and it is reasonable to assume that in man the same process occurs. This finding in dogs has long been known, and we have only confirmed the observation. But more important, we believe, is the fact that this experimental method can be wisely utilized to recognize in an unknown quinine derivative the presence or absence of the blinding factor, and hence save the human from such complications. Naturally these experiments in protection and toxicity consume time, and frequently the results are confusing, so that the words of Burns, "the best laid schemes o' mice an' men gang aft a-gley," seemed to us to be particularly appropriate at times during the past four or five years.

It was Dr. Cretcher's idea at the beginning of this research to attach to the complex molecule of quinine the hydroxy radicle, as it was known that at times this chemical arrangement reduced the toxicity and did not greatly interfere with the bactericidal or antiseptic power of the substance. Ethylhydrocupreine (optochin) and ethylapocupreine were both known to have strong bactericidal power for the pneumococcus, the latter being the more potent. The hydroxy radicle was fairly readily added to optochin, producing hydroxyethylhydrocupreine, known to us as No. 7. It was much less toxic than optochin, but its anti-pneumococcic power was also considerably lessened. This preparation was never used other than in experimental work. However, the chemical development of the hydroxyethylapocupreine was much more difficult. After about one year we were able to get a sufficient amount to test in animals and found that it had little toxicity and considerable bactericidal power, although less than ethylapocupreine. Hydroxyethylapocupreine for this reason was of great interest, and particularly so, when we found that it had no blinding factor for dogs. It was not until the winter of 1935–36 that we were able to

get sufficient quantities of it to use in clinical pneumonia, and it was soon recognized that this chemical did not produce visual disturbances in the human. During the first year (1935–36) the amount of the chemical was very limited because at that time there was only about 5 per cent. yield. Fortunately, a new process was found during the summer of 1936 by Dr. Butler which raised the yield to about 40 per cent. Hence, during the winter of 1936–37 we have had an adequate amount for our clinical work.

We have seen during the past two years, in treating about 200 cases, not the slightest evidence of blindness. Furthermore, the dosage has been very large in many cases, from 400 to 800 grains or even higher during a week's time. The usual daily dose, for adults, is 120 grains a day, and it can be kept up for several days. It is given like quinine in capsules by mouth. It possibly can be given effectively by bowel, but we have had as yet little experience with this method, which may be very useful in the future for those cases that develop nausea. It can not be injected into the muscle, as it causes necrosis with subsequent abscess formation, at least if given in large doses, as is necessary in pneumonia cases. This winter we have given by vein the hydroxyethylapocupreine to a number of the very sick cases. In only one instance are we certain that a reaction associated with a blood pressure fall resulted. Locally, however, we expected and have seen a good deal of thrombosis of the veins at the point which receives the injection. The substitution of the acid salt, the dihydrochloride which we have used, by the neutral salt, the monohydrochloride, might lessen to a considerable degree the incidence of thrombosis in the veins. This problem is now being investigated. On only two occasions have we noted slight ringing in the ears, so commonly associated with even moderate dosage of quinine. This year nausea has been one of the frequent clinical symptoms associated with severe influenza. It was not noted in the previous year, and we, therefore, believe that its occurrence is not due to the chemical, although it may be intensified by its use.

As to our results for the past two years, we can say that the hydroxyethylapocupreine appears to be effective in a considerable number of cases. Unfortunately, during the past winter many of our pneumonias have had mixed infections. The *streptococcus haemolyticus* and the *Bacillus influenza* have been isolated from the sputum, blood and lungs many more times than in the previous years. The pneumococcus is present in practically all cases in addition. The hydroxyethylapocupreine has no bactericidal action as far as we know on influenza or on streptococcus infection. We treated in the first year about 50 cases and more than double that number during the past year. Very few cases were treated after the fourth day of the disease, for one can expect very little to be accomplished in late cases, as is also true for the specific type 1 serum. The majority were treated in the first three days. In going over our figures for the past two years, just two weeks ago, we were surprised to note that our mortality was very much lower in cases of pneumonia when treatment by the chemical began on the third day, than on either the first or the second day. This observation was the same for each year and the number of cases seemed to be large enough to strongly suggest something more than chance or statistical error. This finding one can very easily control next year. There may well be a reason for this difference in the mortality on the third day and if this proves to be correct in a larger series of cases the observation will have great practical importance as the mortality on the third day was only 4.7 per cent., while on the first day it was 26 per cent. and on the second day 34 per cent. This year for 100 cases treated we have had a 27 per cent. mortality; our normal mortality for 100 non-specifically treated cases in hospital work in Pittsburgh is

about 45 per cent. There has been a definite difference in the mortality in the positive blood culture cases during the past two years. In 47 positive blood culture cases that were treated, 19 recovered, whereas, in 26 cases that were not treated, usually because they were late in the disease and therefore not true control cases, only 4 recovered. We are of the opinion that the mixed infection this year has increased the mortality and that likely in non-influenzal epidemic years it would be lower. As the mortality in pneumonia varies from 20 to 45 per cent. in different communities, it is important in comparing the results of treatment to note the relative change in mortality. In other words a 50 per cent. reducing in our mortality would still leave us with a figure as high as that reported for many other cities in the country. A proved reduction in mortality, however, in any given community should be applicable to all places.

At the end of two years' clinical trial we are impressed by the possibilities of hydroxyethylapocupreine. Clinical observations take time, and it will probably be several years before the exact place of this chemical in the treatment of pneumonia can be estimated. Naturally, our results must be confirmed by others.

An interesting observation associated with pneumonia has been the treatment of empyema, one of the common complications of severe infections. The pus in the pleural sac is aspirated and, depending upon the amount removed, a 1 or 2 per cent. solution of hydroxyethylapocupreine is injected into the pleural cavity. Never more than 100 cc have been injected. The aspiration of the pus from the pleural cavity and the injection of the chemical is repeated several times, depending entirely on the clinical picture of the patient. We have not had any case this year requiring more than four injections. There will be, undoubtedly, an occasional case of empyema where the pus can not be reached by the needle and where drainage tubes will have to be inserted. The 1 or 2 per cent. solution of the chemical can then be used through the drainage tubes in the same way as Dakin's solution is now employed. Empyema carries a low mortality, but with the usual past methods of treatment it has been a slow process before the patient is cured. The injection method appears to shorten considerably the time of illness, and to lessen the discomfort of the patient by avoiding the excision of a piece of rib or the introduction of drainage tubes into the pleural sac. Optochin has been used occasionally in the past in the treatment of empyema by others and by us. We have also used ethylapoquinine, but in the past two years have substituted hydroxyethylapocupreine, as it is quite safe and in the stronger solution quite as effective. We have not had many empyema cases during the years 1935–37, about 12, but the results have been uniformly good. This, of course, does not apply to empyema produced by the streptococcus, as on this organism the quinine derivative has little or no action.

In conclusion, we can safely say that in hydroxyethylapocupreine we have developed a quinine derivative which is devoid of any visual disturbance and which appears to have power in affecting a certain number of pneumonia cases in man. Its exact clinical status will have to wait until a larger number of cases have been studied by others and by us. That opportunity, we hope, will be forthcoming to a considerable degree in the near future, when a larger supply of the chemical will be generally available. This chemical is compatible as far as we know with the use of any form of serum which may be given in certain types of pneumonia, and further the ease of administration will make it very available for the general practitioner of medicine to use early in pneumococcic disease of the lung.

QUALITY IN HUMAN POPULATIONS

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STUDENTS of population, having amassed vast quantities of data, now find themselves a little embarrassed by their riches. Having refined their statistical methods to a degree of accuracy permitting them to venture into prophecy, they have become uncertain as to what their predictions bode for the welfare of man. Being able to plot the differential growth of various categories within the population, they are faced with the necessity of justifying their labors by determining whether the threatened quantitative changes have any significant qualitative correlates. It is obvious that if one class of the population is increasing more rapidly than another, this fact, however interesting, has no fundamental significance for the essential quality of the population if the classes are differentiated by merely ephemeral distinctions. The problem facing population experts, therefore, centers around the effort to discover what qualitative judgments can be safely made concerning the various categories with which they can deal, and to what extent these qualities rise from genetic origins.

This problem of quality has many aspects, but the one considered here is concerned with the methods employed by physical anthropologists of determining physical quality. It is not easy to summon from the clouds of vague verbiage which cluster around the concept of physical quality any significant contribution to its understanding made by physical anthropology or more strictly anthropometry. But on the reassurance that a critical, even a negative, attitude might embrace a positive gain, I have been induced to undertake a survey of the fruits of anthropometry in the hope that by clarifying its aims and its point of view I might thereby define its potentiality for those concerned with the qualities of populations.

But before making safari into the anthropometric jungle where physical anthropologists seek their quarry, let us first examine the nature of the quarry itself in the hope of explaining thereby the jungle which we must traverse. For I believe, to use less figurative language, that the aims of physical anthropology have shaped its means. What, then, are the aims of physical anthropology and how have they shaped the anthropometric means which we use in striving to attain them. In answer to this question I should like to sketch very briefly the history of physical anthropology for the benefit of the perspective it provides. We might begin in true Teutonic fashion by dredging in the wells of antiquity for the first mutilated fragments of Greek or Egyptian wisdom on the subject. We might, perhaps, with somewhat more justification consider the preoccupation of the renaissance painters and sculptors with the esthetic canons of the human body. But in reality we should find that physical anthropology as an organized discipline sprang from natural history and anatomy at a period when these as well as other sciences were less sharply differentiated than they are to-day. The catalytic agent responsible for its precipitation from the contemporary scientific solution was the problem of the racial classification of man. Bernier, in 1684, was perhaps the first modern to offer a

racial classification. He divided mankind into four principal stocks: (1) Europeans, including with great liberality the north Africans, the Hindus and the American Indians; (2) Africans; (3) Asiatics; (4) Lapps. With the confidence of that innocent age Bradley, a professor of astronomy at Oxford, who looked through both ends of his telescope with equal ease, followed Bernier with a notable classification based on hair. Leibniz, the philosopher, added still another. But it remained for Linné in 1735 to give wide circulation to the idea of a racial division of mankind based on scientific observation. In this same period or immediately following we discover such illustrious names as Buffon, Kant, Maupertuis and Blumenbach associated with inquiries into the varieties of man. But these men, deeply read in the natural history of their times, employed the anecdotal and the subjective method in their lucubrations. Even in more favorable circumstances their cabinets of cranial specimens were more often objects of curiosity and contemplation than of applied, systematic study. Leaving aside the investigations of human proportions for esthetic purposes which appear to be of greater interest in retrospect than they were in reality, one of the first impulses to achieve objective criteria in the classification of man came from Peter Camper, whose device of the facial angle was posthumously published in 1792. This angle measured the degree of facial prognathism and proved of enormous value in differentiating various groups of mankind.

The early nineteenth century successors of Blumenbach, who is frequently labelled the father of physical anthropology, included such men as Bory de Saint-Vincent, Pritchard, Nott, Glidden, Virey, Pickering and many others. They continued to depend largely on description and anecdote, although some unorganized data derived from objective measures were creeping into their learned and derivative literary monuments.

Towards the middle of the nineteenth century Carus in Germany and Morton in America appeared as exponents of a more exact and objective technique. Both these men were deeply stimulated by Lavater and Gall, whose discredited hypothesis on the association of character and cranial conformations have nevertheless proven fertile in a number of fields. By the middle decades of the century, the science of measuring the human body in an effort to establish criteria of race was already in a flourishing condition. To mention only a few outstanding workers, Retzius had invented the cephalic index, Virchow was busily engaged in measuring and describing skulls brought from the ends of the earth, Broca in France was laying the foundations of instrumentation and standards of exact measurement, and Quetelet was applying statistics to the measurements on the living body. The vast bulk of all these efforts still remained directed toward the elusive classification of man. This singleness of purpose continued with only an occasional lapse into alien territory down to the present century. It is true that the study of prehistoric man began to loom large in the middle of the last century, that evolution and the relationship of man to the primates captured the attention of the physical anthropologist after 1859, but these were in a sense only other aspects of the same taxonomic industry. For our immediate elders the culmination of this monogamous marriage of physical anthropology with race occurred when Martin in 1914 issued the first edition of his "Lehrbuch der Anthropologie," which later appeared in three heavy, exhaustive volumes. Here was summed up the science of anthropometry. Although Martin did not attempt to include every anthropometric measurement proposed or even employed up to that time, neverthe-

less he did pile up the impressive total of some 225 measurements and indices. One might suppose from this that the human body offered no additional dimensions and that nothing was left to measure, but, in addition to these, new measurements were and still are constantly being suggested with ever diminishing returns. Besides these strictly measurable characters, which include lengths, widths and girths of head, face, trunk and extremities, physical anthropologists also take numerous observations on non-measurable, or so-called qualitative traits, such as pigmentation of eye, hair and skin, form and distribution of hair and degrees of development of numerous anatomical features.

It must now be more than apparent that physical anthropology has been remarkably constant to a specific goal and that its technique was created mainly to serve that goal. Measurement after measurement has been added to uncover ever finer and more reliable criteria for racial classification. But the racial classification of man is essentially an anatomical one, concerned with gross external features and without consideration of quality or value. Just as the taxonomist in any zoological field regards his specimens without moral judgment, simply as ordered physical variants which can be made to fit into a pattern, so the student of race with some exceptions has striven to consider the varieties of man. His measures are purely physical ones and are not designed to give answers to questions of good or bad in quality, high or low in survival value, rich or poor in efficiency. Within normal ranges we can not say whether tall or short stature is preferable, whether dolichocephalic or brachycephalic heads are wiser, whether brown or blue eyes are keener, whether leptorrhine or platyrrhine people live longer or whether short- or long-trunked individuals are more efficient. Yet these are the kind of criteria upon which racial distinctions are based. It may be that some of the anthropometric measures have an index of survival value and may be rated as to quality. But if they can be so classified, the investigations of the physical anthropologist are not calculated to serve such a purpose. A little later I hope to mention the beginnings in this direction which hold forth promise for such future judgments.

Assuming for the moment that a racial classification of man is both necessary and feasible, and I believe it may be defended cogently, we may then ask if races are stable and preserve their identity through the ages and in differing environments. This seems to me not only a fundamental question for the understanding of race itself but of great importance in the problem of evolution. The first scientific investigation of this problem appeared some 25 years ago, when Professor Boas measured the children of immigrants to the United States. He discovered not only that the children born in this country underwent certain changes in stature and cephalic index but also that these changes were greater the longer the residence of the parents in this country before the birth of the child. These conclusions met with a storm of opposition and misinterpretation, and they failed to fertilize anthropological thought.

In 1930 on the invitation of the University of Hawaii I undertook to carry out some studies on the Chinese-Hawaiian hybrids. Such an investigation obviously demanded a knowledge of the parental groups, Hawaiian as well as Chinese. Since the Chinese were newcomers it was essential to know if they had suffered any physical alterations since their arrival in Hawaii, where living conditions are widely different from those in China. To insure an adequate genetic control I determined to investigate not only the Chinese immigrants to Hawaii and their children born in Hawaii but also their relatives in their native villages in China.

This study proved sufficiently promising to encourage its extension to the Japanese in Hawaii. In this latter group circumstances were even more favorable for such a study, because the immigration was more recent, the immigrants themselves more restricted in their origins and their relatives in Japan consequently more accessible for study. The Japanese in Hawaii were first introduced as labor on the sugar plantations. Two major waves occur in the general stream of migration. The first appeared between 1884 and 1890 and the second reached its apex sometime around 1900. Laborers were recruited largely from the prefectures of southern Hondo, the main island of Japan, and from the nearby districts on the neighboring island of Kyushu. Our data on the Japanese fell into three main groups: (1) The Hawaiian born Japanese of pure Japanese parentage; (2) the immigrants born in Japan but migrant to Hawaii in early manhood; (3) the sedents, who are the relatives of the immigrants and represent the original population born and bred and living in Japan. I have adopted the term "sedents" because I could find no single word in English to describe those who, unlike the emigrants, remain at home. All three groups are of the same genetic lines.

The results of our investigation although not yet published are now available. They reveal, according to my interpretations, two phenomena of great significance. We have evidence here, I believe, of selection and of modification by environment. It is my belief that the immigrants represent a selected population, differing significantly from the sedents. In 37 out of 50 traits or in 74 per cent. of the comparisons the immigrants and sedents diverge to a statistically significant extent. The immigrants, compared with the sedents, have relatively shorter trunks, wider shoulders, narrower hips. Their chest is relatively wider and shallower. Their arms and legs are longer despite the similarity in total stature. Their faces are longer and wider at the level of the gonial angles. Their noses are longer and narrower. These are only some of the more striking differences between the two groups. Since both groups are intimately related by blood, and since both were born in Japan and raised to maturity there, the conclusion seems inevitable that the difference between them is the consequence of some form of selection. There was, however, no conscious selection on the part of the recruiters who merely accepted any able-bodied laborer willing to venture to Hawaii. It is, of course, clear that economic pressure played a significant part in inducing the immigrants to leave their native land. They were younger sons, landless and without prospects in their native country. It is easy to speculate on what might have been the fundamental selective factor which was able to gather out of a population so definite and distinctive a sub-type, but I shall leave that for another place. I wish merely to make the point here that the Japanese immigrants to Hawaii represent a deviant selected from the type most commonly encountered among the sedents.

When we come to assess the children of the immigrants born in Hawaii and raised under what we regard as far better environmental conditions, we discover a series of marked changes largely dependent on an increase in size. The Hawaiian born are 4.11 cm taller than their fathers; and although considerably younger than the immigrants they are heavier by four pounds; their trunks and legs are longer; their shoulders are wider. But it is necessary to note that these are all proportionate and harmonious changes, the indices remaining unchanged. In other words, the disproportions of the immigrants are maintained in the Hawaiian born, but

modified by increases in bulk. But in addition to this increase in size combined with stability in proportion among the Hawaiian born when compared to their immigrant parents, we also observe a number of alterations in proportions largely concentrated in the cephalic and facial parts. Unexpectedly the head length decreased, despite an increase in stature and in bulk, while the head width increased, thereby causing the cephalic index to rise. This was a phenomenon observed in Boas's data. But in this wider setting the change is less characteristic. Without dwelling too long on the details of this investigation, I believe it demonstrates the manner in which populations may alter their racial characters. Their quantitative traits are subject to modification by selection and perhaps more significantly by environment, whatever that may be.

Although physical anthropologists in general resist the idea that their races may be malleable under fluctuating conditions, many of their data support this hypothesis rather directly. For example, the progressive increase in stature of European populations has been noted by a number of investigators. In Germany, Sweden, France, England and America this phenomena has been demonstrated in army and college statistics. In this connection I must mention that the Japanese are also exhibiting increments in height, but these do not account for the prodigious jump in the Hawaiian-born Japanese, who far exceed their contemporaries in Japan.

Still another corpus or perhaps other corpora of data are susceptible to a similar interpretation, although other explanations have been offered. These are the studies which reveal that the more favored socio-economic classes and the urban dwellers in homogeneous and long-settled areas tend to differ from the surrounding population not only in their physical dimensions but in physiological traits such as onset of menses.

Before I pass on to another aspect of race I wish to make it clear that I am not defending an inherent capacity for unlimited change. All we have any right to suggest from the present data is that within certain limits a given racial group or stock may alter the dimensions of its physical characters and its proportions by a selective process or by modification induced by environment.

Having in this manner, by necessity briefly and elliptically, reviewed the history of racial investigation, described the creation of a technique to measure race, mentioned the recent trends in the study of race, it might well be asked what if anything does race offer us for the assessment of physical quality. I think the answer is clear from the preceding remarks. Nothing. The pursuit of a racial classification has been objective, concerned with visible, easily distinguishable traits subject to measurement either by calibrated instrument or by standardized scale. The physical anthropologist has never sought to determine whether the Polynesian is superior to the Malay, the Chinaman more enduring than the African or the whites preferable to the Mongols. He has only attempted to find the key to their classification by physical characters in order to establish their relationship and to understand their evolution. A certain class of unscientific and impressionistic writer, in almost every case non-anthropologists, who have sought to associate race with ideas of superiority and inferiority, are not, it seems to me, worthy of discussion in this company. On the other hand, the more serious attempts by psychologists to correlate race with psychological characters, especially the intelligence quotient, had a striking and apparently brief existence. Following Brigham's study of intelligence in the draft, hosts of disciples busily engaged themselves in plaguing tolerant but puzzled children and even uncomprehending savages with questions

cleverly designed in the laboratory. The results of these earnest studies have been severely criticized by various writers.

Physiologists, however, have only made a beginning in the study of racial physiology. Such tests as the metabolic rate have been measured on a number of differing groups. Benedict, for example, finds that the Maya Indians have higher rates than North American whites, but that Chinese and Hindus have lower ones. As yet, however, these results are still tentative and have been denied in some quarters. Age at menarche shows some variation, but whether these fluctuations are racial or environmental is open to question. But the significant fact remains that the few physiological distinctions claimed to be correlated with race are not reliable criteria of quality.

It may, at this point, be pertinent to discuss briefly the nature of classification, as it affects the various efforts made to superimpose one system upon another. The efforts of physical anthropologists to classify man illustrate with exceptional clarity one of the difficulties of classification. So long as the criteria remained few the task was simple and satisfactory. All men could be neatly divided into large categories without distressing non-conformities and irritating exceptions. But with each addition to the battery of criteria the job becomes progressively harder. Instead of each new criterion correlating perfectly with the previous ones it tends to overlap and blur the previously established categories. Similarly physiological, psychical, psychological and social classifications refuse to fit exactly the racial classification. They overlap, they blur and they confuse. Each separate system is based on distinct criteria which may or may not be moderately correlated with race. But even if they were correlated, the correlation would never be perfect, and consequently to read the one by the other dangerous. It is here that the fundamental weakness of relying on physical race or stock for determining quality appears. Man, scientists not excepted, is prone to the easy fallacy of association. Presented with a classification of physical man, he soon seeks to squeeze all other systems into the same frame. If he finds, as he believes, that 60 per cent. of one racial category of mankind is established on farms and only 50 per cent. of another, then the former group is inevitably characterized as agricultural and the second non-agricultural, and if farmers happen to be the favored element in the population the second group has a rather rough time in the ensuing discussions. This is hardly an exaggeration. The literature is full of such examples of associational overlapping of disparate classification which in the resulting conclusions are treated as though the associations were complete and perfect. They hardly ever, I venture to say never, are.

I have, I hope, made clear that the technique of physical anthropology is designed to analyze physical race, which in turn is a purely zoological concept without connotation of quality; that race itself is subject to certain limited fluctuations dependent on selection and environment; that as yet we have no basis for correlating measures of physiology and psychology with race; that if we had, the physiological ones so far investigated are not susceptible to quality judgments, although the psychological ones might be so interpreted. But here lies the danger previously noted of incomplete association of one system with another, the danger of overlapping, which invalidates race as a final touchstone.

Thus in tackling race in an effort to reach the goal of quality judgments, we find the anthropometric studies of no assistance. What then can the physical

anthropologist with his anthropometry offer the student of population who finds himself at an impasse? For, certainly, the population expert must wonder what his data signify in the future of his population. When he terrifies the lay public with charts of declining fertility, with graphs designed to show that the urban population is dying out, that the college population refuses to reproduce itself and that the Southern hill-billies threaten to replace the northern people, is he certain that the waning groups are actually better than the waxing ones. This is what the student of population really wishes to know and how to preserve these better elements if they really are superior.

I should like now to discuss briefly several lines of research which seem to me to offer some possibility of assistance to the questioning student of population. They represent recent developments in which physical anthropology has played a part. First, I shall touch on the study of constitution. The Kretschmerian association of body type with manic depressive and schizophrenic forms of insanity reopened an ancient, Hippocratic approach. Pende, Draper, Bauer, Krause and many others have carried this association of body build into the realm of disease. Draper, for example, claims a high degree of correlation between leptosome structure and gastric ulcer and between brachysome types and gall bladder disturbances. The underlying theory here is that deviant forms of body build create stresses and strains on correlated anatomical systems which thus become more liable to breakdown than others. Reed and Love have suggested similar associations. They found that T.B. is more common in tall, thin men than in short men, either thin or heavy. These authors also found that valvular diseases of the heart resulting from acute infectious and rheumatic fevers were more frequent in tall, thin men. It should, of course, be mentioned that these investigations of disease and structure are not universally accepted. Many of them have been based on extremely weak evidence and too few have been checked by other workers.

An interesting application of the concept of constitutional type appears in a study carried out by Bach. For example, gymnasts compared with men excelling in field sports were found to be short, heavy and broad, with large trunks; whereas the field athletes were tall, light in weight, narrow and long-legged. These differences appeared to be independent of racial or geographical factors. Similar conclusions were reached by Brezina and Lebzelter from a study of constitution and occupation.

The relationship of constitutional type to race is not altogether clear. Saller regards constitution as distinct from race and declares that races differ in the frequencies of the diverse constitutional types. Czekanowski and others concur in this opinion. And yet criticism has been directed toward the notion of constitution on the ground that it has confused the ideas of race and constitution.

Admitting the diagnostic value of constitution and accepting the claims that constitution and disease are associated, we still need to know whether or not constitution is a function of environment and whether it is correlated with race or geographical groups. We might, then, if not before, be justified in asking whether certain constitutional types are worse or better than others. And in response to this I know of no convincing studies. Perhaps some people would prefer to die of one disease rather than of another, but they would all be subject to *a* disease and eventually die. At best constitutional studies might tell us what diseases might be likely to attack certain people, but unless there is an age correlation I venture to suggest that in the health of the race it is not of paramount

importance which disease is fated eventually to carry off the population. But should a scale of values be possible in grading the biological and social consequences of disease groups, then, always assuming the significant association of disease with constitution and constitution with biological groups of man, the qualitative aspects of these studies may prove of great value to the student of populations. But here as in other associations with race the correlation at best can never be perfect.

Before leaving this class of investigation I should like to mention another field of study which has some points of contact with constitution and some bearing on this discussion of the anthropometric approach to quality. I refer to the investigation of the rôle of the endocrines in the structure and function of the human organism.

At this stage in the progress of endocrinological research it would amount to supererogation to insist on the vital importance of the hormones in shaping not only our temperaments but our bodies as well. The vast amount of experimental work along these lines have amply demonstrated that. The consequences of the over-functioning of the pituitary in producing giantism, the effect of the gonads on sexual differentiation, the effect of hypofunction of the thyroid in a lowered metabolic rate are universally accepted. Dentists also are coming to recognize that the teeth are affected by disturbances in calcium metabolism. But the interrelation of the various internal secretions and their adjustments to the organism as a whole are enormously complex. Because of this interlocking system it is extremely difficult to isolate the essential nature of any one endocrine gland. In recent years huge strides have, however, been taken in the analysis of the endocrine function of experimental animals, but knowledge of the detailed relationship of the hormones with *human* structure and character has lagged behind.

Eleven years ago when I first began to take systematic measurements on various endocrine dystrophies, there were no objective data available on the effect of the endocrines on various anthropometric characters; and with the exception of Sir Arthur Keith's very general speculations on the interrelation of race and endocrines and Nikolaew's hypothetical remarks on the same subject nothing concrete existed on this suggestive interrelationship. The possibilities for the understanding of human variations inherent in endocrine research have not yet been fully apprehended by physical anthropologists. I should like to cite in passing a few beginnings into this promising realm. Rowe has suggested that the hypo and hyper status of the various glands determine size and body proportion. The classic work of Tandler and Grosz and of Pittard on the Skotpsy, who are members of a cult which practices castration, revealed the profound effect which the gonads exercise in controlling the development of the body. Very recently Pearl investigated the weights and sizes of the endocrine organs in subjects from an insane asylum. Although his study does not fall within the frame of the present discussion of anthropometry, nevertheless his findings have some bearing on the problem. His general conclusion appeared to be that on a percentage basis of the whole endocrine system the insane were below normal in the gonads and thyroid and above in the others, particularly in the thymus, parathyroids and adrenals. No patterns were, however, discernible in the various psychiatric groups.

From the as yet fragmentary data on the influence of the hormones on body structure, one might hazard the opinion, without too much reliance on wishful thinking, that future research will reveal

an interdependence of body structure and endocrines. Although the problem is more elusive, it is probable that temperamental as well as other psychological and intellectual attributes will similarly be found to be bound up with the ductless glands. Here is another avenue toward the eventual alliance of anthropometry, quality and population.

I have perhaps now arrived at a point where I may attempt to summarize what hope physical anthropology can at present hold out in determining quality in population. But before I do that I must first lay the ghost whose troubled ectoplasm has been hovering at this feast. I have quite deliberately refrained until now from discussing the fundamental question on which all this hinges. I had interpreted quite literally my premise and have sought to lay before you, negatively I am afraid, the anthropometric approach to the concept of quality of population. For purposes of introducing the physical anthropological philosophy I have assumed that we all know exactly what quality is. Remember, I speak only from the physical point of view, leaving aside questions of social behavior and intelligence, where perhaps the answer is clearer. If the human species were valuable as is the cow for its milk-producing virtues or as is the sheep for its fleece, then the problem of determining human quality would be much simplified. There is, of course, the all-too-human tendency to resolve the dilemma by regarding all who are different from oneself as of poorer and less desirable stuff—and by extension to even larger groups, for Nordics to belittle the Mediterranean, for whites to depreciate the Negroes and for man to deny the monkeys. Yet, as I have said before, what do we actually know of the relative virtues of the races of man, assuming it were possible to establish them in a hierarchy of physical virtue? We must, it seems to me, have a definite concept of what physical quality is before we can seek it and above all before we can measure it.

I shall with some trepidation and with considerable temerity make an effort to set up a definition of physical quality. Above all, it seems to me that physical quality should be characterized by efficiency. If the organism is ill-adapted to its function of living, it is poor in physical quality, whatever may be its intellectual capabilities. Lack of physical efficiency may, of course, be expressed in a great variety of ways, for example, in susceptibility to disease, lack of resistance to stress and fatigue, presence of abnormalities which interfere with function and of course mental incapacity. I have without any special research drawn up a list of commonly accepted factors which might seriously lessen physical efficiency: (1) Idiocy; (2) insanity, such as schizophrenia; (3) epilepsy; (4) blindness; (5) deafness; (6) chronic ill health; (7) malformity; (8) emotional instability.

You might perhaps be able to suggest other causes frequently found to interfere with physical efficiency, but they would in all probability fall into similar categories. I wish you to note that none of the commonly accepted disabilities just listed fall within the province of anthropometry, except perhaps malformity. In other words, if we measure poor quality by lack of efficiency, we discover that the very factors inhibiting efficiency are largely non-anthropometric. Because no one has ever sought to measure the relative physical efficiency of normal variations in human proportions, we do not know whether or not one type is a better machine than another. Here is a neglected field well worth cultivation.

To the definition of physical quality as efficiency we might also add survival value. But survival value, if interpreted to mean longevity, physical drive and

fertility, likewise eludes the calipers. Its criteria are gauged by other methods than anthropometry.

I thus come to a rather negative conclusion when I state my belief that the immediate dangers of deterioration of population exist in characteristics not subject to or in most cases not amenable to anthropometric methods. In my opinion the traditional studies of physical anthropology—namely racial classification—have as yet nothing to offer of value in determining physical quality. But the chill of this negative may be tempered with the expectation that from the study of constitutional types and from investigations of endocrine control of human growth and development some light may be generated to clarify the definition and recognition of quality.

Finally, I can not forbear closing my remarks with a plea and a testimonial. I have discovered that the discipline of ordering my ideas for this paper, that the necessity of capturing nebulous dissatisfactions and of clothing them in words, has revealed a point of view of which I was previously only vaguely aware. I wish to make a plea for this point of view. I should like to see a reorientation in physical anthropology. Like the artist who finds it necessary constantly to refer back to life, the physical anthropologist must return to the living subject and reconsider him not as a static object but as a living dynamic, functioning organism. He must relate his data, his measurements, his proportions and his various traits and characters to the functions which gave them birth. He should seek to learn how all these anthropometric characters serve their organism, which are best suited for their task and what specifications make the best machine for a given purpose. We must create a whole new field of anthropometric research, designed to investigate the effect of normal as well as abnormal variations in human structure on the mechanics of the human organism. I would envisage a discipline in which health, physical vigor, longevity, fertility, physical efficiency were studied in terms of the functioning structure, not only physiologically and psychologically but anatomically as well. Perhaps if we achieve that, we may then serve the student of population.

THE COLORING OF FOOD: ITS USE AND ABUSE

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THE addition of color to food adds nothing to its nutritional value. In a few instances the color may appeal to the eye, but this appeal does not compensate for the many fraudulent purposes for which it is used.

Color is seldom used in the preparation of food in the household, except, for example, in the coloring of mint jelly and possibly in the coloring of frostings. In many instances the commercial use of color causes the food so colored to resemble the uncolored home-cooked variety.

Because of the possible fraudulent use of color in food, the statutes necessarily provide means of control. The coloring of food is occasionally permitted by law. The Massachusetts statutory definition of butter and cheese contains the following words, "and with or without coloring matter." All frozen desserts are, strange to say, required by the Massachusetts law to be colored, the definition of ice cream, for example, being, "a pure, clean, frozen product made from a combination of milk or cream or other milk product, with or without eggs, *but with* water, sugar, and harmless flavoring and *harmless color*, . . ." Those responsible for this definition did not apparently appreciate its real meaning, or the color addition would have been made permissive, as in butter and cheese. The courts, however, have not yet been called upon to convict a person for selling ice cream free from color.

The use of color in confectionery is impliedly permitted by the law, which prohibits the use of colors only if poisonous.

Color is not specifically mentioned in the Massachusetts milk law, but its use is prohibited by a statute penalizing the sale of milk containing any added foreign substance.

The Massachusetts statute specifically prohibits the use of color in the manufacture of sausages, it provides that vinegar is adulterated if colored, and it also prohibits the sale of oleomargarine containing any added coloring.

Apart from the above specific references to certain articles of food, the addition of color to food is governed by the General Food and Drug Law, which declares that food is adulterated, "Fourth, If it is mixed, colored, powdered, coated or stained in a manner whereby damage or inferiority is concealed." This is the wording of the United States law, of the Massachusetts law and of the law of most of the other states. The wording is not so satisfactory as was that of the old Massachusetts law, which it replaced. That law, found in Section 18 of Chapter 75 of the Revised Laws, now repealed, declared food to be adulterated, "Sixth, If it is colored, coated, polished or powdered in such a manner as to conceal its damaged or inferior condition, or if by any means it is made to appear better or of greater value than it is." Under the present law, it is not a violation to add color to food to make the article appear of better value than it is.

The human animal has many peculiarities regarding the color of his food.

The white versus brown egg obsession is one of these peculiarities, people in New England preferring the brown eggs presumably because most of the New England hens lay the brown variety, whereas people in New York prefer the white eggs because most of the hens in that locality lay the white variety. The white eggs from California are, consequently, shipped to New York and the brown eggs from California or from other states in the West are shipped to Massachusetts.

The preference in apples is for a red apple, although there are apples of different color which taste just as good.

When the golden bantam corn first came on the market it could be sold only with difficulty, because the consumer was of the opinion that it was field corn. It is practically impossible at present to merchandise the black Mexican corn, at least in New England, and there is no particular market demand for yellow tomatoes, although persons growing tomato plants in their back yards frequently purchase plants producing this type of tomato and in many back-yard gardens the black Mexican corn is now grown.

The colors used in food are usually of coal-tar origin and are known to be nonpoisonous. The dyes selected for this purpose have been fed in extremely large quantities to animals without causing any untoward symptoms. The tinctorial power of these coal-tar dyes is far beyond what one not familiar with them can imagine.

The above statement brings to mind an incident related by one of my teachers, the late Professor James M. Crafts. He told the class that he saw at an exposition an enormous block of coal. Beside this were bottles containing the amount of benzene, toluene, etc., which could be obtained from that block of coal and also the very small amounts of certain dyes which could be made from these products of destructive distillation. Beside a small bottle of one of the dyes was a bolt of cloth which the dye could color, and this bolt of cloth assumed the gigantic size of the block of coal from which the small quantity of the dye could be manufactured.

Vegetable dyes are sometimes used to color food. One state formerly had a law prohibiting the use of coal-tar dyes in food, and a confectionery maker stated to me that it was necessary to add more than one per cent. of the total food in the form of vegetable color, in order to comply with this law and at the same time color the articles.

It is usually required that if coal-tar dyes are used for food purposes they must be certified dyes. These dyes are specifically made for food purposes and consist of a small number of dyes of different colors. Each manufacturer sends to the U. S. Department of Agriculture a sample of each batch. This sample is then examined for the presence of possible impurities which may be dangerous, and if these impurities are found to be absent, the batch is then certified. This certification process does not apply to the vegetable dyes.

Confectionery has been colored for many years, and at present no serious harm results. Colors are frequently used to distinguish the flavors. For example, red gum drops are flavored with cassia or cinnamon; black gum drops are flavored with anise; mints flavored with peppermint are, strange to say, not colored, whereas other peppermint-flavored foods, as, for example, peppermint extract, are frequently colored green; wintergreen mints are usually colored red. Lozenges are frequently colored and some manufacturers place them in packages having a translucent cover so that the package presents a harmonious color scheme.

Color was formerly used as an adulter-

ant of confectionery, but this practice ceased many years ago. One of the brown oxides of iron was occasionally used as a color in cheap chocolate to conceal the deficiency in chocolate. There is in the archives of the Massachusetts Department of Public Health a sample of Jordan almonds colored with lead chromate, otherwise known as chrome yellow. The last record of this form of adulteration resulted in two court cases during the year 1891. I am unable to state the result of these cases, but from information received from a person who has passed on, the late Albert E. Leach, former chief analyst, Massachusetts State Board of Health, the defendant in one case ate some of the lead chromate in the presence of the jury.

Color is occasionally used to give a definite article a uniform appearance. The following information was received some years ago from a manufacturer of flavoring extracts. At first he did not use color in his vanilla extract, and naturally the different batches varied in color. Because of this variability consumers assumed that the light-colored extract was weak and the dark-colored extract was strong, which resulted in a discrimination against the lighter colored product. The manufacturer then obtained samples of a number of different batches of this extract and selected the darkest which apparently could be produced, to which he added a small amount of burnt sugar, otherwise known as caramel. This colored extract was then used as the standard, and all subsequent extracts were colored to match it. The public now gets from this manufacturer the same high quality of extract but uniform in color. There is no fraud in the use of color in instances like this.

It is also customary to color many of the other flavoring extracts. For example, a pale yellow is used in lemon extract, and an orange yellow in orange extract, etc. Some manufacturers have been omitting the color from these extracts and have labeled the packages to that effect. Persons using the uncolored extracts can identify them either by reading the labels or by removing the stoppers and smelling the material.

Color was occasionally used in milk in Massachusetts, but there has been practically none used during the past thirty years. The milk dealers using this color frequently paid fifty dollar fines for so doing. By persistent prosecution of these offenders the practice was found to be unprofitable and consequently it ceased.

Partly skimmed milk or milk containing added water to which a little coloring was added looked far richer than whole milk not so treated. The customer often complained to the milkman of the blue color of the milk after the removal of the cream for the morning coffee, and the customer often praised colored and watered milk which looked so rich after being skimmed. The milk trade defended this practice by saying that there was a demand for colored milk. This statement was true, but it was also true that this demand was created by the illegal acts of the trade. Since these illegal acts have ceased the demand for colored milk has gone. The color used was an alkaline solution of annatto sold under the very interesting name of "Milkman's Benefit," but occasionally a coal-tar dye of the methyl orange group was also used.

Sausages are sometimes colored, and the regulations of the Bureau of Animal Industry of the U. S. Department of Agriculture permits the practice under certain restrictions. The Massachusetts law, however, prohibits the use of color in the manufacture of sausages and prohibits the sale of colored sausages. Under these conditions, certain U. S. inspected and passed foods can not be legally sold in Massachusetts.

Color is used on smoked sausages of the frankfort and bologna type because it simulates the result of the smoking process and therefore reduces the time of smoking and also prevents the loss of water which would otherwise occur by a more prolonged smoking. On one occasion, when the department found color being used in U. S. inspected frankfort sausages, it was believed that this was done because of the partial substitution of pork for beef. Paprika is frequently used in sausages of the frankfort type. Although paprika is a spice and may be legally used, its utilitarian purpose in this instance is because of its color.

One retail dealer used a very ingenious method to take advantage of his customers' color sensitivity. An inspector of the department saw in a showcase of a retail market some frankfort sausages which he believed were colored. He made a purchase and brought the sausages to the laboratory. When the package was opened in the presence of the inspector he was surprised to note that the sausages were not colored and the analysis subsequently showed his surmise to be correct. The inspector believed that the clerk in the store knew him and had substituted some uncolored sausages while wrapping the package. The inspector at once returned to the store and investigated. A red electric light bulb was concealed in the showcase, thus accounting for the observed color, which, however, was not considered a violation of the law. Another example of a similar use of color is a yellow milk bottle.

Color may be used in jams and jellies for legitimate or illegitimate purposes. Mint jelly is apple jelly in which some mint leaves are cooked, and the jelly is usually colored green even when made by the consumer. Apart from this, the use of color in jams and jellies is for fraudulent purposes and conceals the scarcity of the fruit of which the article is presumed to be made.

Tomato ketchup was formerly extensively colored until new methods of manufacture were developed which did not destroy to any great extent the natural color of the tomato, and at present many brands of tomato ketchup are not colored.

French peas were colored by boiling in a solution of copper sulfate. The copper combined with the albuminous material on the outside of the peas and produced a green color. The Massachusetts State Board of Health many years ago prosecuted a Massachusetts wholesale house for the sale of this variety of peas, alleging injury to health. The defendant put many reputable physicians on the witness stand, all of whom testified that the copper in the peas was not injurious to health. The case resulted in a finding of not guilty. Subsequent to this case, the importer continued to import and sell this variety of peas, but he took pains to label each package to the effect that the contents of the package were supposed to contain copper to an extent not exceeding a certain specified quantity.

One of the regulations of the U. S. Secretary of Agriculture is to the effect that copper can not be used in food on account of its alleged injurious action. This regulation has been adopted by most of the states, and while it may have no standing in the United States courts, it certainly has a standing in the state courts. The sale of vegetables artificially greened with copper is now practically nil.

The use of color is permitted in butter, cheese and ice cream, but it is prohibited in oleomargarine. The reason for the prohibition is very evident, as without the color oleomargarine can not be sold as butter. The argument in favor of

adding color to butter is that there is no particular harm in making butter a little more yellow than it naturally is or in making butter produced in the winter months look like butter produced in the spring after the cows have been put out to pasture. This argument was formerly more valid than it is at present, because we now associate the presence of certain vitamins with the natural yellow color of butter.

After Congress placed a tax of ten cents a pound upon colored oleomargarine, the manufacturers naturally found difficulty in selling it uncolored because of its resemblance to lard. They then changed the character of some of the fats, and as one of the ingredients included June butter, which was naturally of a very heavy yellow color, they also used unbleached oils and selected oleo oil of a fairly heavy color, whereas prior to that time they used bleached oils and white oleo oil. If oleomargarine is colored, it can readily be sold as butter with but little complaint from the purchaser.

The presence of color in ice cream may cause it to look good. It may distinguish the different flavors, but a yellow color most certainly gives a creamy appearance often in excess of the cream concentration. In order to correct this deceptive appearance the statutes provide for a fat standard, in some states higher than in others.

The Massachusetts fat standard is 10 per cent., but the fat content of the average ice cream sold in Massachusetts is about 15 per cent. Ice cream with a very high fat content is naturally sold at a higher price than is ice cream with a low fat content, and therefore the addition of color does practically no harm because the consumer is getting about what he is paying for.

This argument regarding color in frozen desserts does not apply to sherbets. A mixture of sugar, water or milk, with a little citric acid, some oil of orange and a little color will resemble a superior article made from orange juice, sugar and milk or water, but will be a far inferior article because of the absence of the anti-scorbutic vitamin which makes orange juice so highly desirable.

Practically all soft drinks are colored, caramel being used in the dark beverages, such as sarsaparilla and root beer, a red color is used in the so-called strawberry or raspberry preparations, and the orange preparations are colored yellow. Most of the carbonated orange preparations consist of carbonated water, sugar, citric acid, color, a colloidal cloud and a little orange oil. These preparations are usually sold as orange soda, although some of them are mislabeled with the word "Orangeade." Orangeade, according to the dictionary, consists of orange juice, sugar and water. Because of this difference in the character of the two drinks, the consumer should learn to distinguish between the meaning of the two terms, orange soda and orangeade.

Another orange preparation, consisting of a little orange juice, somewhat less of lemon juice, sugar, water and color has been put upon the market in recent years, and its sales are apparently on the increase. Much of this material is sold by the milk dealers. The reason for the addition of the lemon juice is very interesting. Lemons contain six times as much citric acid as do oranges, and therefore for each volume of lemon juice in the mixture the manufacturer can save six times as much orange juice by the addition of sufficient sugar and water to take its place. Frequently citric acid is used in this preparation in place of lemon juice. The manufacturer will say that the lemon juice or citric acid is added to bring out the flavor of the orange juice, but it is difficult to understand this explanation when the analysis indicates a substantial reduction in total

fruit juice. Many of these commercial preparations show upon analysis less than 15 per cent. of total fruit juice calculated as orange juice, but calculated from the citric acid and sugar content alone show the equivalent of 30 per cent. of orange juice.

The U. S. Department of Agriculture has recently made a ruling to the effect that the interstate shipment of these preparations, if colored, and even so labeled is a violation of the Food and Drug Law. This regulation has no force before a United States Court. The United States has made no prosecutions, but the interstate shippers have been sending the concentrated material in interstate commerce without the addition of color and have sent the color in another package with the intention of having the retailer add the color and take his chances with the state food enforcement officials. A representative of one of these interstate shippers was asked why not ship in interstate commerce some colored orange concentrate and invite federal action. He replied because of multiple seizures, together with the expense of defending all of them. I am aware of no court decisions upholding the above ruling. A case should be tried in the U. S. courts and the ruling should not be passed on to the states for enforcement.

Some Massachusetts dealers omitted the color, and several milk dealers who did so claimed a loss in trade to competitors who sold this material with the color added. As this loss in trade was also accompanied by loss in milk business, the dealers were somewhat provoked. It is rather strange that the addition of a small amount of color to a food preparation would have such an effect upon its salability.

There has recently developed a practice of coloring oranges. This is carried on to the greatest extent in the State of Florida. Persons usually judge the ripeness of an orange by its color. Citrus fruits do not ripen after being picked from the tree, and in this characteristic they are different from many other fruits, which can be picked green and which will ripen in transit.

The representatives of the Florida orange industry state that all ripe fruit is not yellow and, unless colored, the consumer will not purchase it. The organization claims that by their process of commercial handling no fruit is colored except fruit that is ripe. According to the regulations of the U. S. Department of Agriculture, each orange which is so colored must be labeled upon the skin to that effect.

Not only soft drinks but hard drinks as well are frequently colored. Wines depend for their color upon the color of the grape skins from which they were manufactured, but a great many years ago the Massachusetts Department of Health had occasion to prosecute a man for selling a wine fermented from commercial glucose to which had been added some salicylic acid and some artificial color. This, however, is unusual. Distilled liquors of the gin or schnapps type are not colored. Many of the cordials are colored, and this is also true of practically all the whiskey. Freshly distilled whiskey is white. If it is placed in an oak barrel for the purpose of being aged, it absorbs color from the barrel. If the barrel is charred on the inside, as is the custom in the United States, the whiskey in addition absorbs the color produced by the charring process. If the whiskey is a blend, it is diluted and flavored alcohol, to which may be added some aged whiskey, and the mixture is then colored with burnt sugar.

Color is sometimes used in olive oil sold to the Italian and Greek people. For some reason, these persons prefer a green olive oil, and the green color is fre-

quently added to cottonseed oil mixtures containing a small amount of slightly rancid olive oil.

Chopped meat is often colored by the addition of sodium sulfite. This practice is permitted by the Massachusetts statutes, provided that the sodium sulfite content is not in excess of one tenth of one per cent. and provided further that the presence of this chemical is made known to the purchaser by an appropriate label on the outside of the package. This material is sometimes added to fresh beef sausage, and by the Italians to fresh pork sausage. Red meat darkens upon exposure to the air. The sulfite reacts with some of the constituents of the meat proteins and produces a red color which makes the article look like fresh meat. The sodium sulfite also acts to some extent as a deodorizer, but its preservative properties are too slight to be of any practical value.

Sodium nitrate, otherwise known as saltpeter, and more recently sodium nitrite, are also used in curing meat. During the process of curing, the nitrate if used is reduced to nitrite at the expense of some of the meat; consequently, the addition of sodium nitrite is now permitted by the regulations of the U. S. Bureau of Animal Industry. Meat cured in this way will develop a red color on cooking, and the flavor is somewhat different from that of meat cured with salt. Some people like it, others do not. The meat so treated is usually sold as being saltpeter cured.

Cake made by bakers is sometimes colored yellow in order that the consumer may imagine that it contains more eggs than are actually used.

Color was formerly used to cover up certain types of adulteration now obsolete. For example, charcoal was mixed with black pepper, adulterated so far with starch that it was necessary to add a little cayenne to give it a kick. Mustard, diluted with more than half its weight of wheat flour, was colored with turmeric, and so-called custard powder, consisting of tapioca starch, was sold in two packages, one, not colored, representing the egg white and the other, colored yellow, representing the egg yolk.

Nearly forty years ago I heard the late Dr. Samuel W. Abbott, secretary of the Massachusetts State Board of Health, say to a legislative committee: "Gentlemen: If you pass a law prohibiting the use of color in food you will do more to stop food adulteration than by any other means." Even to-day there is considerable truth in that statement.

THE ELECTRICAL STATE OF THE EARTH'S OUTER ATMOSPHERE

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On August 25, 1936, shortly after noon, the pilot of an airliner in South America found that radio signals from his base at Lima, Peru, some 200 miles north, had suddenly disappeared. From 1:26 P.M. until 2:43 P.M. absolutely no communication could be effected on any high radio frequency. At Seattle, Washington, a radio operator, who was communicating with ships at sea, reported that at exactly the same time ship-to-shore communication on the high radio frequencies dropped out entirely and remained impossible for more than an hour. Subsequent investigation showed that throughout the central portion of the sunlit hemisphere all high-frequency radio circuits were simultaneously interrupted during the same interval.

Closely Related Phenomena

This wide-spread interruption of radio services was only one part of a far-reaching effect. At Huancayo, Peru, the Institution's Department of Terrestrial Magnetism maintains a magnetic observatory to record the strength and direction of the earth's magnetic field, the electrical currents in the earth's crust, the electrical state of the upper atmosphere and other related geophysical effects. Observers there noted that at precisely the same moment, that is, 1:26 P.M. (Eastern standard time), the earth's magnetic field suddenly increased in intensity, simultaneously shifting its direction slightly. Likewise the currents in the earth's surface fluctuated violently. Investigation shows that these effects were observed throughout the central portion of the sunlit hemisphere.

Regularly scheduled observations of the sun were commenced a few minutes later by observers at the Mount Wilson Observatory of the Carnegie Institution with the spectrohelioscope. To quote from Dr. Richardson's report:

> On August 25 a brilliant sunspot-eruption was first seen on a hydrogen spectroheliogram taken at $18^h 58^m$. (This was 1:58 P.M. eastern standard time.) No observations are available for an hour preceding this time. . . . Successive exposures taken at intervals of four minutes . . . show the flocculi decreasing in brightness until about $19^h 22^m$ (2:22 P.M. eastern standard time), when the appearance of the region was normal. This fade-out and sunspot-eruption resemble those of April 8, 1936, when the phenomena were observed to occur simultaneously. We can not definitely establish that the fade-out and eruption of August 25 were simultaneous, but from our knowledge of sunspot-eruptions it does not seem unreasonable to assume that the outburst may have begun about $18^h 30^m$ since 28 minutes later it was definitely on the decline.

The recent discovery by Dellinger and by Jouast that radio fade-outs of wide-spread influence occur in the sunlit hemisphere has been followed almost immediately with the recognition that they are accompanied by solar and magnetic effects which have been described. On April 8, 1936, such an occurrence was observed in all its phases by the observers at the Huancayo Magnetic Observatory. Fig. 1 shows the simultaneity of these events at this observatory. The spectroheliograms of the sun have been kindly supplied by the Mount Wilson Observatory because photographic methods are not available on the spectrohelioscope at Huancayo. Mr. Scott, who was observing on the spectrohelioscope at Huancayo at this time, witnessed the commencement of this solar eruption and, realizing its unusual character, hurriedly called Mr. Torreson, the observer-in-charge. Both agree that it was one of the brightest

eruptions which has been observed at Huancayo.

Here, then, we have examples of effects observed on the sun and simultaneously on the sunlit hemisphere of the earth, including a brilliant sunspot-eruption accompanied by a cessation of high-frequency radio communication and violent fluctuations in the earth's magnetic field and in currents flowing in the earth's crust. The question arises—how is it possible for an eruption on the sun to have such wide-spread effects on the earth? What is the physical mechanism by which such an eruption can interrupt radio communication, can change the force and direction of the earth's magnetic field, and can affect currents flowing in the earth?

The example which I have cited describes only one type of the numerous relationships which we know to exist between solar changes and terrestrial effects. It was realized as early as 1843 by Schwabe of Dessau that the number of sunspots varied systematically over a period of about 11 years, that is, the time-interval between the occurrence of minimum numbers of sunspots. As the numbers of sunspots vary, the magnitude of fluctuation and frequency of disturbance of the earth's magnetism changes similarly, so that magnetic activity is greater when sunspots are more numerous. The auroras and earth-currents are related in a like manner to solar and magnetic activity. Then there is the 27-day recurrence tendency. If a magnetic disturbance or a severe radio disturbance occurs to-day, it is probable that one will occur 27 days from to-day, and perhaps again 54 days from to-day. Now this period of 27 days is the average time required for a sunspot to rotate from a position toward the earth, around the sun, to a position toward the earth again.

All these facts show that not only are magnetic activity, radio transmission, auroras, earth-currents and similar phenomena closely related, but they are also related definitely to events, some visible and some invisible, which occur on the sun. We must again repeat the question—what are the physical mechanisms by which events on the sun have such wide-spread influence on the earth? What is the nature of these emanations from the sun which cause these terrestrial reactions? Such questions have been troubling investigators since the inception of studies in meteorology and terrestrial magnetism.

Attempts to Explain Relationship

A start toward the proper solution was made with the masterly mathematical developments of Gauss just about a century ago when he showed how it was possible to separate the magnetic field of the earth into two parts—one part originating inside the earth and the other originating in regions external to the earth's crust. Not enough magnetic data from widely separated locations were available at this early date to permit him to conduct the actual operation for the variations of the earth's field. His work did, however, greatly stimulate the construction of magnetic observatories which made such a separation of the magnetic variation-field into its internal and external sources eventually possible.

In 1882, Professor Balfour Stewart published the first suggestion that daily fluctuations in the earth's magnetism must arise from an electrical condition in the earth's outer atmosphere. He proposed that this electrified outer atmosphere formed the bond between effects on the sun and the related geophysical changes which were observed on the earth.

It is worth while to read from Stewart's conclusions. He says:

> We are thus driven by the method of exhaustions to look to the upper regions of the atmosphere as the most probable seat of the solar influence in producing diurnal magnetic changes, and it need only be said that the only conceivable

magnetic cause capable of operating in such regions must be an electrical current. Now we know from our study of the aurora that there are such currents in these regions. . . . A good deal has been said about the difficulty of imagining a daily set of currents to be generated in the regions of such imperfect conductivity but . . . there seems ground for believing that their conductivity may be much greater than has heretofore been supposed.

Balfour Stewart thought, however, that the electrical conditions affecting the earth's magnetism must exist at about the upper cloud-level, which we now know to be much too low. Sir Arthur Schuster succeeded Balfour Stewart as professor of physics at Manchester in 1888, and a year later he published the results of a mathematical analysis conducted along the lines which had been earlier suggested by Gauss. In this, he conclusively proved that certain variations in the earth's magnetic field must originate in a region exterior to the earth's crust.

The conclusions of Stewart and Schuster found only limited circulation outside their field, so that in 1900, when Marconi made his first transmission of radio waves across the Atlantic, engineers were at a loss to know how radio waves were bent around the earth. It appeared that as radio waves were of the same nature as light, they should travel off into space at a tangent to the earth. In 1902, Professor A. E. Kennelly, of Harvard, and O. Heaviside, an English engineer, both apparently unaware of the earlier deductions from terrestrial magnetism, independently proposed that an electrically conducting region must exist in the earth's outer atmosphere which reflected the radio waves back to the earth. This is the well-known "Kennelly-Heaviside layer" designated by the more general name "ionosphere." Professor Kennelly tentatively assigned a height of about 80 kilometers (50 miles) to this region, a height since shown to be very nearly correct.

Here, then, were two independent phenomena—terrestrial magnetism and radio-wave transmission—each of which required the existence of an electrically conducting region in the upper atmosphere to explain its effects. It now but required the tools to prove directly the existence of such an electrified region in the outer atmosphere and to show its characteristics. This problem was undertaken simultaneously by Appleton and Barnett in England, by Breit and Tuve, of the Department of Terrestrial Magnetism in Washington, and by Taylor and Hulburt, of the United States Naval Research Laboratory in Bellevue. Each group used a different method.

The method of Breit and Tuve was the most simple and direct, and now almost universally forms the basis for modern methods of ionospheric measurement. They reasoned that if the ionosphere was at about 100 kilometers (60 miles) in height, it would take about six ten-thousandths of a second for a radio wave, propagated at the velocity of light, to travel up to the ionosphere, to be reflected and to return to the earth. Then if a pulse of radio waves of a much shorter duration, perhaps one or two ten-thousandths of a second, were transmitted upward, the reflection should be returned and observed quite distinctly a few ten-thousandths of a second after the transmission had been completed. The experiment was conducted between the Department of Terrestrial Magnetism and the Naval Research Laboratory. Not only were definite reflections observed from the ionosphere, but they were of such character as to indicate that a complex electrical structure must exist.

This, then, forms the basic experiment around which the structure of our modern studies of the ionosphere have been erected. It establishes definitely that the outer atmosphere must contain electrically charged particles in large numbers, which is exactly the condition required to explain the efforts of terrestrial magnetism and radio transmission.

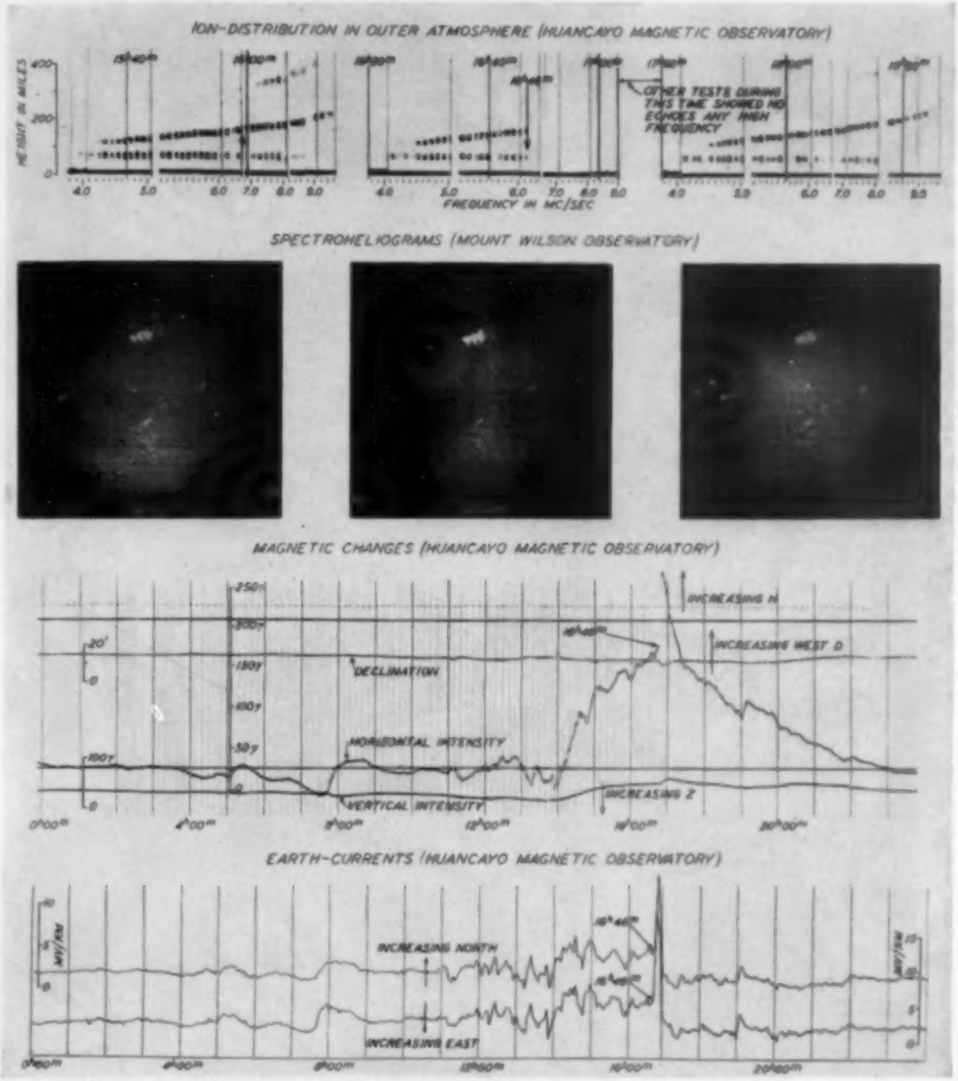


FIG. 1. MAGNETIC, RADIO, AND EARTH-CURRENT DISTURBANCES ASSOCIATED WITH THE BRILLIANT SOLAR ERUPTION OF APRIL 8, 1936.

EXPLORING THE IONOSPHERE

With the reality of the ionosphere established, the question arises—what is the mechanism within this medium through which the sun influences terrestrial magnetism, radio transmission and the other effects which we have mentioned? The answer to this question is the objective of modern research into the electrical state of the upper atmosphere.

To obtain the answer it is necessary that we first learn how these electrically charged particles or ions are distributed through the outer atmosphere. What is the density of ions at each height above the earth and how does this density change from hour to hour, day to day, season to season and year to year? Furthermore, we must learn something of the physical structure of the outer

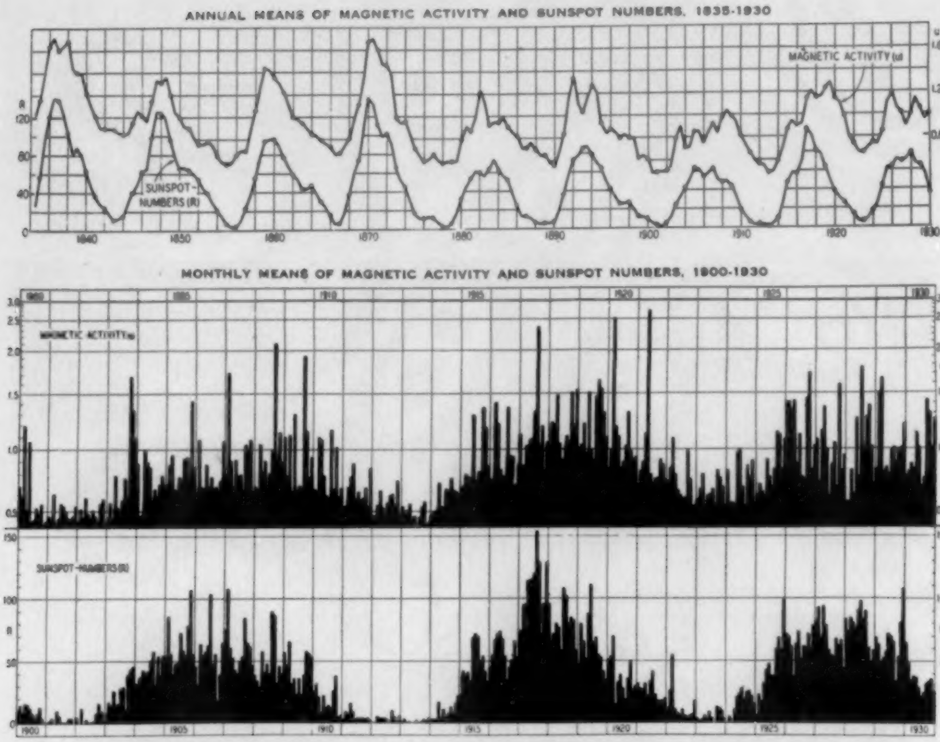


FIG. 2. MAGNETIC ACTIVITY IN RELATION TO SUNSPOT NUMBERS.

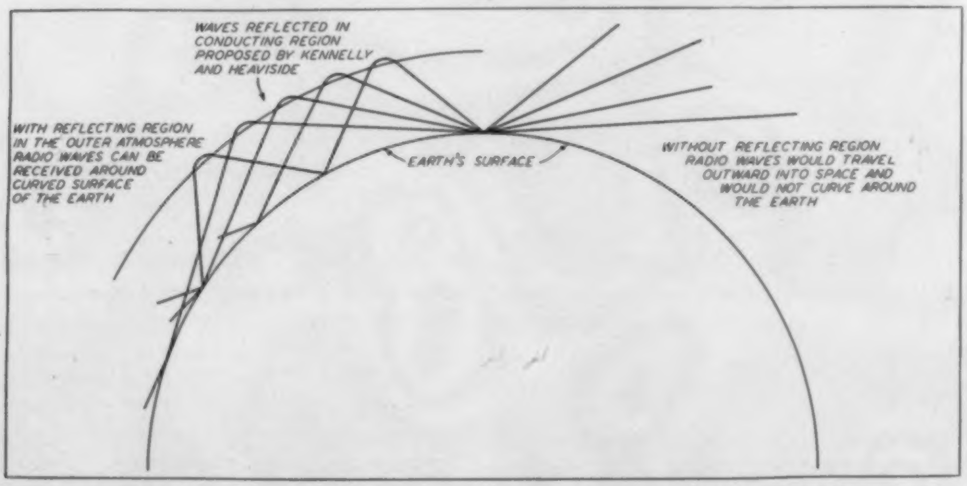


FIG. 3. EARLY RADIO EVIDENCE FOR AN ELECTRICALLY CONDUCTING REGION IN THE OUTER ATMOSPHERE.

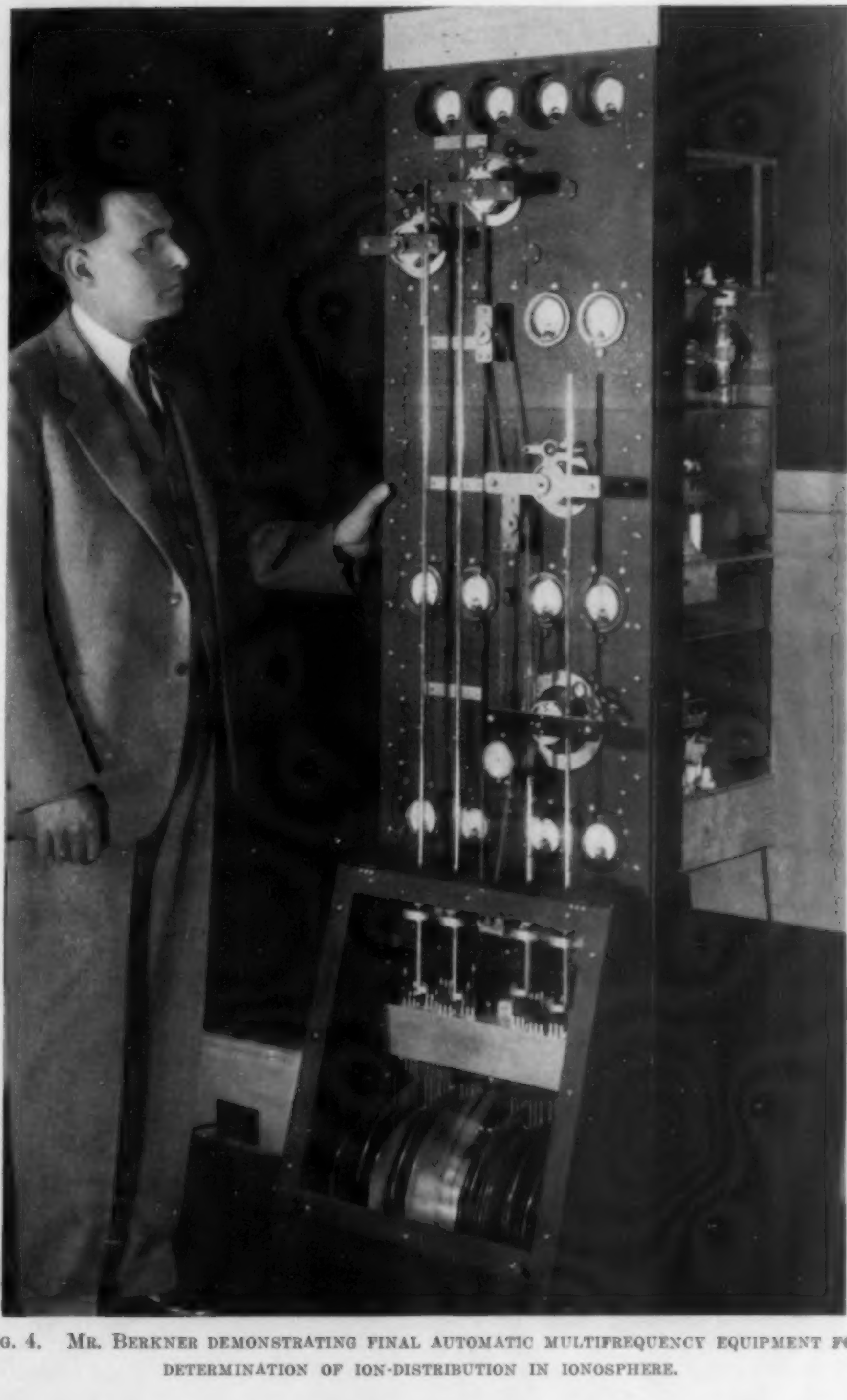


FIG. 4. MR. BERKNER DEMONSTRATING FINAL AUTOMATIC MULTIFREQUENCY EQUIPMENT FOR DETERMINATION OF ION-DISTRIBUTION IN IONOSPHERE.

atmosphere, of its constituent molecules and atoms, of its temperature.

Before discussing these things, permit me to preface my remarks with a brief description of the radio method by which many of them are determined. To observe the number of ions at each height throughout the upper atmosphere, the experiment of Breit and Tuve has been extended.

You may recall that in their experiment a pulse of one or two ten-thousandths of a second was sent upward and the height of the reflecting level was determined from the time required for the reflection to return. Suppose, for instance, that we wish to know our distance from an inaccessible cliff. If we make a loud noise, as by firing a gun, we will hear the echo return. Now sound travels one mile in 5 seconds, so if the echo comes back 5 seconds later we know that the sound has traveled one mile and that the cliff is therefore half this distance or one half mile away.

In this analogy, the radio transmitter is the gun and the sound becomes the radio wave traveling at the constant velocity of light throughout virtually all its path (300,000 kilometers or 186,000 miles per second). As a consequence, the echo-time is very short—it requires about one one-thousandth of a second for the wave to travel to a height of 100 miles and return. Thus we can determine the height from the travel-time for the transmitted pulse.

Now the number of electrically charged particles, or ions, which cause the wave to be reflected depend upon the characteristics of the transmitted radio wave. If the pulse of radio waves is transmitted directly upward, this characteristic is simply the frequency of the wave, that is, the number of complete oscillations which the wave executes per second. A wave of a low frequency such as 900 kilocycles per second—a frequency in the broadcast band—will be reflected when it encounters a density of 10,000 electrons per cubic centimeter directly above the transmitter (see Fig. 5). Then if we measure the height of the reflecting level on a frequency of 900 kilocycles per second, we are in reality measuring the height at which a density of 10,000 electrons per cubic centimeter exists.

If we make our measurement on a higher frequency, the wave is more penetrating or we might say that the ionosphere "looked" more transparent to this wave. Therefore, a higher ion-density, that is, a larger number of electrical charges per cubic centimeter, is required for reflection. For instance, a transmission upward on a frequency of 9,000 kilocycles per second will travel until it encounters 1,000,000 electrons per cubic centimeter before it is reflected. If such a high density of ions does not exist, the wave can not be reflected but will continue to travel into outer space and will be lost. Then for each frequency there is a definite number of ions which will reflect the wave at normal incidence.

This, then, gives the method by which the numbers of ions at each height can be determined. In practice, a measurement of height is made first on a low frequency. The wave is reflected when it encounters the value of ion-density which corresponds to that frequency, so the height of this ion-density is determined. Then the frequency is increased slightly and another measurement made. This gives the height of the slightly higher ion-density which corresponds to the new frequency.

As measurements are made on higher and higher frequencies, the heights of larger and larger ion-densities are determined until finally the frequency is increased to a value at which it is so penetrating that it can not be stopped by the highest value of ion-density which exists in the region. This frequency is called the "critical frequency," for it tells us the highest density of electrical charges which occurs in the region. Now the measurements on all these frequencies, when combined, give the height of each value of ion-density, and therefore

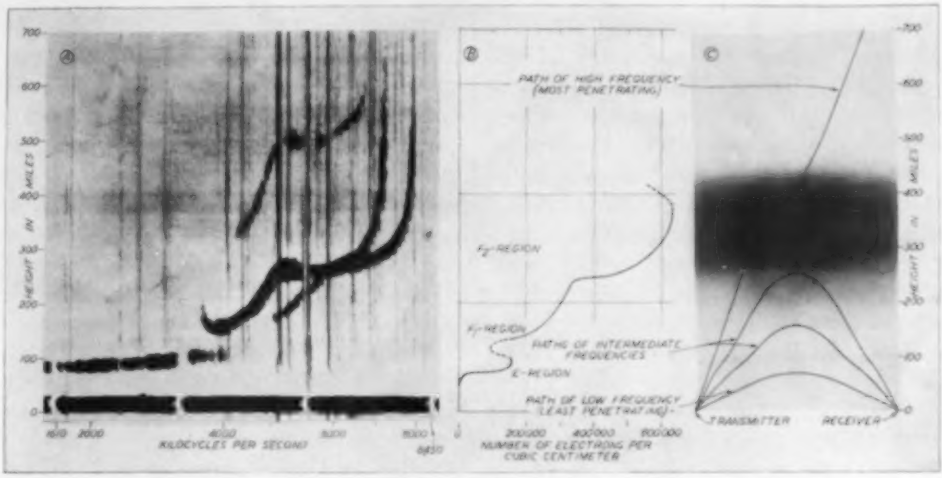


FIG. 5. SHOWING RESULTS OF EXPLORATION OF THE IONOSPHERE. (A) TYPICAL RECORD OF HEIGHTS OF ION-DENSITIES; (B) DISTRIBUTION OF IONS DEDUCED FROM (A); (C) SHOWING PATHS OF WAVES OF VARIOUS FREQUENCIES.

the distribution of ionization through the outer atmosphere.

In the earlier equipment these measurements at successively greater frequencies were conducted by an operator who made each adjustment of frequency manually and who then measured the height of each ion-density visually on an oscilloscope. Such methods were slow and cumbersome. A highly experienced observer required from one to two hours to make a complete determination of the distribution of ionization through the whole of the ionosphere. During this interval the ionosphere might have changed very materially. The first improvement was to record the results photographically. Even then continuity of measurement by such a method is impossible without an unreasonably large personnel.

The necessary simplification of procedure has been attacked at the Department of Terrestrial Magnetism. During the past year an automatic equipment has been completed which makes a record of the entire distribution of ionization throughout the outer atmosphere in 15 minutes. The equipment operates continuously without attention so that four complete records are available each hour. In its design the suggestions of Gilliland have been incorporated to synchronize the transmitter and receiver. Those of you who attended the annual exhibition of the Carnegie Institution during last December may recall that the automatic equipment of this type which is to be placed at the magnetic observatories of the Department of Terrestrial Magnetism was demonstrated there.

The automatic equipment, however, is the result of a long research only now nearing completion. In the meantime it became evident that to understand the vagaries of the ionosphere, measurements must be made at a number of locations over the earth. These were in the nature of preliminary experiments to determine the nature of the problem and to guide the design of the final equipment so that its ultimate requirements might be fully met. To accomplish this purpose more simple, if less complete, manual equipment was sent into the field. One such unit is located at the Huancayo Magnetic Observatory of the department.

Huancayo, Peru, is about 12° south of the equator and almost directly south of Washington near the 75th meridian. This location is on the magnetic equator

—a position of considerable importance, as will be seen. A second unit is at the Watheroo Magnetic Observatory of the department, about 30° south of the equator at 116° east longitude. These stations, in conjunction with the station of the National Bureau of Standards at Washington with which close cooperation is maintained, have made possible a comprehensive approach to the world-wide aspects of the ionosphere. In the ensuing material I have drawn freely from the excellent published data of the Radio Section of the National Bureau of Standards, particularly of my former associates Kirby, Gilliland and Judson, to make the world picture more complete.

Regions of Ionization

We find that the ionosphere is not a simple region of ionization, as was first thought. The original experiments of Breit and Tuve indicated a complicated structure, and early experiments of Appleton showed that two regions must exist. Now we know that it consists of two and, under some conditions, three major regions of ionization. The lower of these regions, technically known as the E-region, is around 100 kilometers (about 60 miles) above the earth's surface, while the upper regions, technically known as the F_1- and F_2-regions, are around 210 kilometers (about 125 miles) and 300 kilometers (about 180 miles) overhead, respectively. These are average values, as the heights vary a good deal under different conditions.

Before we examine these regions in greater detail, let us observe another characteristic of the reflected waves. You will have noticed that certain parts of the curve divide into two branches (Fig. 5); a closer examination discloses that there are really two separate sets of curves, one displaced to the right of the other. This effect appears because of the presence of the earth's magnetic field in the ionosphere and was predicted from mathematical equations before the effect was actually observed. Those of you familiar with physics will recognize it as the Zeeman effect.

Now the waves reflected back from the ionosphere have different charactersitics for each of these branches. Under ordinary circumstances these are quite complicated and we say that they are elliptically polarized. At Huancayo, on the magnetic equator, the earth's field is horizontal overhead and the waves travel at right-angles to this field. According to the theory, the nature of the reflected waves should be much more simple or, as we say, "plane polarized." This matter was examined at Huancayo in experiments conducted by my colleague, H. W. Wells, and they were found to have exactly the nature which the theory predicts.

This effect not only permits confirmation of the theory of reflection but can be used as a tool to study directly the strength of the earth's magnetic field at great heights. It may be that through this mechanism it will be possible eventually to measure small fluctuations of the earth's field in the ionosphere with a highly developed technique. Such an experiment would be of first importance in determining the exact level at which magnetic fluctuations arise.

Imagine traveling upward on a summer noon at Huancayo in some conveyance which could take us to the outer reaches of the atmosphere. Near the earth we find a few thousand ions per cubic centimeter, due to cosmic rays and other sources. From about 25 kilometers (15 miles) to about 65 kilometers (40 miles) we travel in a region in which little is now known concerning the ionization from actual experiment, though it must be relatively low.

At a height of about 65 kilometers we observe the density of ionization to increase, gradually at first and then with increasing rapidity. At about 100 kilometers (60 miles) the increase becomes so sudden that the density of ionization changes by a factor of ten or more within a few kilometers. A little above this,

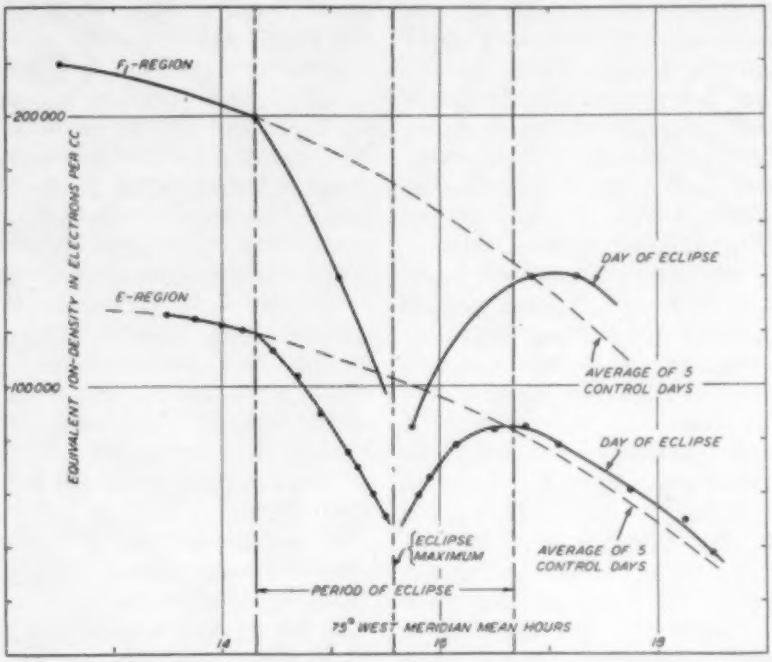


FIG. 6. SOLAR-ECLIPSE EFFECT IN E- AND F_1-REGIONS ON AUGUST 31, 1932, KENSINGTON, MARYLAND. AS THE SUN'S DISK WAS OBSCURED, IONIZATION IMMEDIATELY DECREASED, AGAIN INCREASING AS THE SUN CAME INTO VIEW.

about 110 kilometers (65 miles), we reach the maximum density corresponding to about 180,000 electrons per cubic centimeter. This is the E-region of the ionosphere.

The change just below this height is abrupt, and therefore the term "layer" is sometimes applied. Just above this there is evidence to believe that the ion-density decreases slightly. Then it increases again—very rapidly at a height of about 190 kilometers. The maximum is reached somewhat above 220 kilometers (say 130 miles), where we find that the ion-density corresponds to about 330,000 electrons per cubic centimeter. This is the F_1-region. As we continue upward the ionization remains nearly constant, though it may decrease or increase a little, until at about 300 kilometers (say 180 miles) a third sharp increase occurs. The density of ionization near this level may reach as much as 1,000,000 electrons per cubic centimeter.

It must be remembered that this distribution is for a particular time of day, season and year, and that under other conditions the situation might differ materially. Nevertheless, the first two regions at about 100 kilometers and at about 220 kilometers will be found over any part of the earth as far as we now know, though the maximum densities might differ tenfold.

We have spoken of two regions being present always—the third has a more transient existence. This third, or F_2-region, exists separately only under the more direct rays of the sun. It appears to bulge outward from the next lower or F_1-region. This bulge seems to center directly under the sun, so that at this point the F_2-region is in general highest and most widely separated from the F_1-region below. If we move away in any direction, the height of the upper region falls until it finally merges with the region below. The separation between

the two regions is scarcely distinguishable in a position where the sun's altitude is less than about 45°. Therefore, the F_1- and F_2-regions appear separated only in a circular area under the sun and consequently are in the center of the sunlit hemisphere. This bulge covers an area of about three tenths the sunlit hemisphere. Where the two regions merge at the outside edges of this bulge, the resultant region is known simply as the F-region. Because their ionizations add together, this new region has many of the characteristics of the more highly ionized F_2-region.

Because the earth's axis is tilted about 67° with respect to the plane of its orbit, the center of this area rotates around the earth with the sun along the Tropic of Cancer in the northern summer, gradually shifting to the Tropic of Capricorn as the seasons reverse. At Washington, for example, the separation of these upper regions is quite distinct during the midday hours in the summer when the sun reaches an altitude of about 78° above the horizon, but in midwinter these regions are entirely merged because the sun reaches an altitude of only 28° at midday, when Washington is well outside the 45° zone.

We see, then, that instead of the simple region which was originally conceived, the ionosphere is complicated, involving two main regions with a tremendous bulge above the upper of these to form still a third region of ionization. Why should three regions exist? What is their origin?

Origin of Ionized Regions

We can learn something of this from the characteristics of these regions. We will consider the two regions E and F_1 together because in some respects they are similar in detail. At night the ionization of the E-region is low. The F_1-region appears only after the sun has risen. After sunrise the ionization increases rapidly, reaching a maximum toward noon and decreasing thereafter toward evening. Then in general during the day the number of ions in these regions is proportional to the amount of sunlight upon them.

Let us observe the change of these regions with season. The number of ions is lower in the winter than in the summer. This is true in both hemispheres, so that when the highest numbers of ions are observed at noon in one hemisphere—as during June at Washington—lower numbers are observed in the opposite hemisphere—as at the same time at Watheroo. From this we see that at all times of the year the ion-density of these two lower regions during the day is in general proportional to the sunlight incident upon them.

A final and critical test is obtained by observations during an eclipse of the sun. In 1932 such an eclipse occurred in North America, being about 90 per cent. total at Washington. It is fortunate that for these observations the eclipse need not be total, nor does obscuration of the sun by clouds interfere with the measurements in the least. This eclipse permitted a direct determination of the force active in ionizing these regions. It was found that, as the sun's disk was obscured, the ionization immediately decreased, again increasing as the sun came into view. Because only sunlight can have such an immediate effect, we can conclude that it must be the major source of the ionization of the two lower regions during the daytime.

It is not difficult to ascertain which portion of the sun's light is active in ionizing these regions of the outer atmosphere. We know that the sun radiates light of different wave-lengths, or we may say different frequencies, since wave-length and frequency are directly related. Now the amount of sunlight which we should observe for each frequency if the sun is a perfect radiator can be readily calculated for any assumed temperature.

The frequency of the radiation determines the color of the light; for example, a light-frequency of 8×10^{16} cycles per

second, which is a short way of saying 80 thousand million million cycles per second, appears as a violet, while a lower light-frequency such as 5×10^{16} cycles per second appears as a red color. While higher and lower frequencies than these are invisible to the eye, they may be present and their intensity may be measured. Thus the invisible rays having frequencies above 8×10^{16} cycles per second are known as ultra-violet. The calculated curve then tells us how much energy we should expect to receive from the sun on each frequency.

The amount actually received at the earth's surface has been measured by various observers and is shown by the dotted curve (Fig. 7). These curves match quite well, except in the far ultra-violet. The observed radiation from the sun falls rapidly to zero at a light-frequency of about 10×10^{16} cycles per second, and none of the higher frequency radiation which we should expect is actually observed at the earth's surface. We conclude, therefore, that the difference between the observed and calculated curves must be energy which has been absorbed in the earth's outer atmosphere. A part of this energy is available for the ionization.

There is a fundamental law concerning light which can be written: $E = h\nu$. In this equation E is energy, h is a number known as Planck's constant, and ν is the light-frequency of which we have already spoken.

This is a law of quantum-physics which states that the energy in a photon of light is proportional to its frequency. Then the higher the frequency, the greater the energy involved in a fundamental quantum of light. The far ultra-violet light is of very high frequency, as we have seen, and the photons of such light involve very high energies. When such a photon of high energy reacts on a molecule, it not only can separate it into its constituent atoms but it can also ionize these atoms by ejecting an electron. This is the process which is now believed to occur in the ionization of the outer atmosphere of the earth by the far ultra-violet light of the sun.

The "Anomalous" Region

We have yet to deal with the F_2-region, this outer "bulge" which appears only

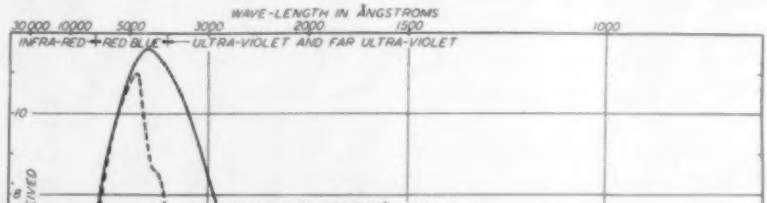


Fig. 7. Absorption of solar radiation in the upper atmosphere from comparison of calculated and observed radiation on various frequencies.

when the sun is high overhead. This region does not behave in the same manner as the lower regions. It is found that violent fluctuations in ionization are common within a space of a few hours, while there are radical differences from one day to another. The trend of change in ion-density during the day is quite different in June and in December, and there are marked dissimilarities in this trend at each of the observing stations, which are widely separated over the earth. This region might be called the "anomalous" region. There are, however, a few features which are common to all stations. For one thing, the changes must be of solar region, as the changes, whatever they may be, occur with a period of the solar day.

When the average of the maximum ion-densities for this region are taken during the daylight hours, in contrast to the lower regions, the highest values occur at all stations at the same time of the year. For example, during June and July, the average ion-density at noon is lower at Washington, Huancayo and Watheroo than the corresponding average taken during December and January. It is a curious fact that the highest ion-densities should occur at all three stations during the same time of the year, in spite of the fact that they are in different hemispheres.

The earth travels an elliptical orbit and approaches nearest the sun early in January, being farthest away early in July. One might suppose that solar radiation of some sort, incident on the earth, should be greater during January than during July. The difficulty, however, is this: While the change in solar radiation received on the earth due to the ellipticity of its orbit is only a few per cent., the observed ratio of ion-density between July and January may be as much as 2 or 3 or even 4 to 1 in some years. A lack of continuity of observation limits the deductions which can be drawn from the limited data at hand.

During the solar eclipse of August, 1932, in North America, observers agree that in contrast to the sudden changes in ionization observed in the lower regions, only a slight decrease occurred in this upper or F_2-region. This observation checks with those made by observers in Russia and Japan during the solar eclipse of June, 1936. However, when observations were being made in North America during the solar eclipse of February, 1935, a very material change of ionization of this upper region occurred.

Here, then, are apparently conflicting data, although, because of the accuracy of the methods used, the reality of the conclusions in each case can not be doubted. However, this conflict gives some clue as to what may be occurring in this outer region. On investigating the dates on which these observations were made, it was found that the upper or F_2-region exhibited an eclipse-effect only when it was merged with the lower F_1-region. No distinct eclipse-effect was observed, however, when they were widely separated. These considerations lead directly to the view that the force which is ionizing the upper region does not undergo any change at the time of the solar eclipse.

In this line of reasoning it must be remembered that it is based upon only a few eclipse-observations in one hemisphere and that any conclusions must be open to question until checked by further eclipse-observations. If an ionizing agent from the sun is not eclipsed at the time of the optical eclipse, it can not be traveling at the velocity of light. This suggests that the ionization of this upper region may be due to particles which are shot off from the sun and which, upon colliding with the molecules of the earth's outer atmosphere, knock off electrons, thus creating the ionization which is observed. Such a hypothesis then proposes the bombardment of the outer atmosphere of the earth by particles from the sun. Such a hypothesis implies certain other conse-

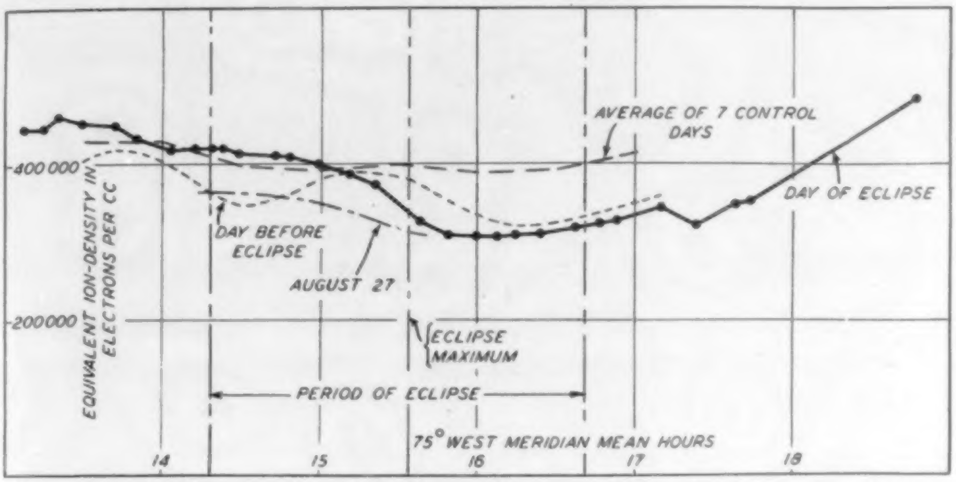


FIG. 8. SOLAR-ECLIPSE EFFECT IN F_2-REGION ON AUGUST 31, 1932, KENSINGTON, MARYLAND.

quences which must be carefully verified by experiment before it can finally be accepted as fact. The necessary checks require (1) a continuity of data which is only now becoming possible with the new automatic equipment and (2) further eclipse-observations which are quantitatively exact.

EFFECT OF ULTRA-VIOLET LIGHT

The main points discussed concerning the electrical state of the outer atmosphere are these. There are three main regions of ionization at heights of about 65, 130 and 180 miles, respectively. Of these, two exist above any location and at any time, as far as we know. The third and upper region appears separately only when the sun is high overhead, merging into the next lower region when the altitude of the sun is low. As these two regions merge, the resultant region takes on most of the characteristics of the more highly ionized upper region which has contributed to it. The major source of ionization in the two lower regions during daylight is the ultra-violet light of the sun. We tentatively suppose the ionization of the upper region to be caused by bombardment of the outer atmosphere by particles emanating from the sun. When the two upper regions are merged to form the single F-region, both sources appear active in producing its ionization.

That two regions should exist which both owe their ionization to the same source—ultra-violet light—presents another problem. A good many suggestions concerning this have been made. The most reasonable at the present time is based upon the composition of the atmosphere itself at these great heights.

Physicists have shown that if we conceive the outer atmosphere to be undisturbed, the lighter gases will rise to higher levels than the heavier gases. At the level of the earth winds are common so that the gas here is continually mixed and the proportion of oxygen and nitrogen remains always constant. At great heights, however, the lighter nitrogen should float to higher levels than the heavier oxygen. Then a ray of light entering the outer atmosphere will have passed a certain number of nitrogen atoms after penetrating through a certain amount of atmosphere. The same ray must penetrate much more deeply into the atmosphere to pass the same number of oxygen atoms. Oxygen is most effective in absorbing certain light-frequencies, while nitrogen is most active in

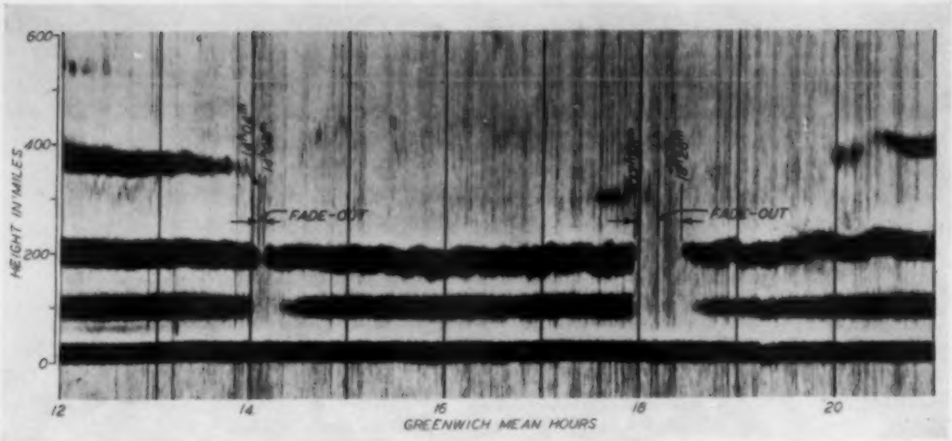


FIG. 9. EXAMPLE OF RADIO FADE-OUTS, HUANCAYO MAGNETIC OBSERVATORY, MAY 28, 1936.

absorbing others. The light which ionizes the nitrogen will be absorbed at a higher level than the light which ionizes the oxygen. Therefore, two distinct levels of ionization would exist, each because of the absorption of a different band of light by a different gas. The difficulty with such an explanation is that as yet we can not be sure whether such a partial separation of gases by diffusion actually occurs in the upper atmosphere and whether the atomic states which have been assumed in this example are actually correct.

Fluctuations in Ionization

As we have seen, it is impossible to observe the very high-frequency radiation from the sun because of its absorption in the upper atmosphere. Some of the characteristics of this radiation can be determined, however, from its reaction on the outer atmosphere. The mean value of ionization is changing from year to year in an orderly manner. We see that so far this change has followed the change in sunspot-activity. In the two lower regions an increase of ionization of about 45 per cent. has occurred since the last sunspot-minimum. From observation in the visible spectrum, the change in the visible radiation during this period appears almost negligible. This suggests that there is much more change in the ultra-violet radiation, which causes this ionization, than in the visible radiation as the solar activity varies, a conclusion which has important consequences in the study of the sun.

When we examine the change of ionization of the third and highest region of the ionosphere since the last sunspot-minimum, we find the change is not 45 per cent. but more than 250 per cent. This not only emphasizes a difference in character of the ionizing forces as already suggested, but implies, on the basis of our hypothesis of particle-bombardment, an enormous change in the number or velocity of particles emitted from the sun as solar activity varies. With regard to these deductions, however, it must be remembered that as yet our observations are available for only about six or seven years and definite conclusions must await operation over a longer period. Nevertheless, deductions from the shorter period are not entirely speculative when we remember the close relationship between sunspot-activity and terrestrial magnetism and, in turn, the dependence of the earth's magnetic phenomena upon the ionosphere.

It will be realized that the changes

which are taking place in these regions must have immediate effects in radio transmission and in the earth's magnetic field which depend upon them. For example, a few years ago certain police radio stations were assigned to a frequency of about 43 megacycles per second because then this frequency was high enough to penetrate the ionosphere. Therefore, the range of these stations was limited to their immediate vicinity.

To-day, as the result of the enormous increase of ion-density in the F_2-region, these stations are frequently heard in Europe. Thus, to provide the best service with the minimum of interference to other services, suitable allocation of stations to proper frequencies depends upon a knowledge of the fluctuations of ionization in the upper atmosphere. The best frequency for transmission across the Atlantic this year may not be the best next year, and a quite different one may be desirable.

At the beginning of this paper we mentioned cases of coincidence of a brilliant solar eruption with certain geophysical effects. Suppose we examine in a little more detail what has happened in the ionosphere during such an occurrence (Fig. 9). At the beginning of the eruption all reflections faded out suddenly, staying out for its duration. When echoes again appeared, the upper regions were essentially the same as they were before the eruption. This demonstrates that the upper two regions were not affected, but that the region below 100 kilometers was so strongly ionized that it completely absorbed the radio waves without reflecting them.

The importance of this localization has been recently emphasized by my colleague, A. G. McNish, who has pointed out that the character of the disturbance accompanying the solar eruption is intimately associated with the normal diurnal variation of the earth's magnetic field. Such information adds to the accumulating evidence which must eventually determine in which ionized region magnetic fluctuations find their source. Likewise the change of ionization in the lower regions with the years has a definite relation to changes in the activity of the earth's magnetic field.

Important Effects Unmentioned

In presenting this picture of our present knowledge of the electrical state of the earth's outer atmosphere, I have been limited necessarily to a description of some of the basic facts so far uncovered. In assessing these it has been necessary to pass over a multitude of observed effects, each of which contribute definite facts to aid in the construction of the theory. There are, for instance, the sudden sporadic ionizations of very great intensity at the 100-kilometer level. These can occur at any time of the day or night; they are found more frequently during the summer months in any location; they occur more frequently toward the polar regions, practically never occurring at the magnetic equator. During such times the upper regions may be entirely invisible to the exploring radio wave because of the great intensity of this ionization, and phenomenal radio transmissions on ultra-high frequences occur. It has also been necessary to leave the night effects entirely unmentioned.

We see, then, that this outer atmosphere of the earth, once believed isolated and inaccessible, is now yielding to exploration by attack with modern experimental tools. Effects of the first rank, which might otherwise have passed unnoticed, have been discovered through observations at widely separated stations. Despite the relative vacuum in the outer reaches of the atmosphere, the events which occur there play a definite and important part in the scheme of things. In learning the facts concerning these regions, we increase our comprehension of the events taking place around about us.

ROCKEFELLER CENTER, LOOKING WEST.
THE MUSEUM OF SCIENCE AND INDUSTRY IS LOCATED ON THE FIRST FLOOR OF THE TALLEST BUILDING.

THE LAYMAN WANTS TO KNOW

By ROBERT P. SHAW

ACTING DIRECTOR OF THE NEW YORK MUSEUM OF SCIENCE AND INDUSTRY

and MARION CLYDE McCARROLL

WHAT, in science, interests the layman? That, in brief, is the question to which the New York Museum of Science and Industry has been seeking a definite answer in the twelve years since a bequest in the will of Henry R. Towne started it on its way.

For the museum was created specifically for the average person, as a place where the mysteries of science would be made plain to him in simple visual demonstrations; where he could acquire at least an elementary working understanding of the terms on which he is able to live and work and play in a universe run by inexorable scientific laws.

When the museum's move from its previous location in the Daily News Building to more commodious quarters in Rockefeller Center was consummated it undertook to give the public a chance to speak for itself. At certain times throughout the day and evening—and the museum is open to the public every day in the year from ten in the morning until ten at night—members of the museum staff strolled about the place and entered into casual conversation with visitors, with the idea of discovering what brought them into the museum and what their particular interests were in the varied exhibition about them.

The results of this strolling questionnaire have served to confirm many of the conclusions at which museum officials have been gradually arriving throughout the past twelve years of their experience. It has been established first of all that the answer to the question with which this article opened is as simple as it is comprehensive and *vice versa*. One single word covers the whole matter. What, in science, interests the layman? Everything.

Out of something over three thousand persons questioned within one month, there has emerged a composite layman who, like Kipling's famous elephant's child, has an "insatiable curiosity" about the mechanics of the world in which he finds himself. There is nothing about which his lively imagination does not play, no stone of knowledge which he is willing to leave unturned, lest something of vital interest or significance should escape him. There are, naturally enough, some things that intrigue him more than others, and hence it is only logical that of these three thousand people, a little more than a third should have come to see an exhibit in some specific field. But the range of these special interests covers so wide a territory that, after the most careful survey, it is found only to give added emphasis to that comprehensive "everything" which expresses what the public is interested in on the scientific side of life.

Furthermore, there are four main things this composite average person wants to know about matters scientific; four questions that he asks, to which the museum exhibits must supply the answers. These are: "What is new in science?", "What is its history?", "How does it work?" and "What does it mean to me?" In other words, the novelty, the background or development, the operating mechanics and the practical application of scientific achievement must all be supplied in order to give the layman the picture he wants.

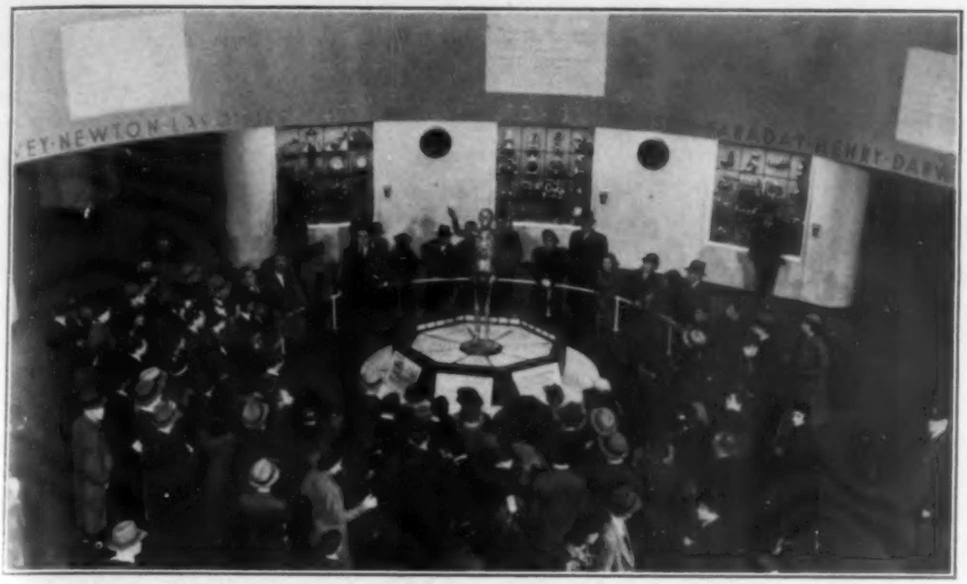
With this background, then, of defined public sentiment added to twelve years of what might be called the experimental method of scientific presentation to the layman, the Museum of Science and Industry is evolving a considered policy which seeks to approach the matter from the main indicated angles. It is doing this by means of a threefold program as follows: First, through permanent exhibits which serve as background in basic fields; second, in special temporary exhibits of a news character, which show some striking scientific achievement for the first time or present a comprehensive view in compact form of scientific development along one particular line; and third, through various demonstrations in which the scientific side of some practical everyday matter is presented by a lecturer using a graphically dramatized operating exhibit by way of illustration.

One other thing has been a guiding principle in the minds of those who have worked out the present program of the museum. That is, that scientific principles can be most readily grasped by the lay mind where they can be seen actually at work and that if an exhibit can be operated by the individual himself it is most practically valuable of all.

So, wherever possible, exhibits have been arranged so that they can be set in motion by the simple pressure of a button by the visitor himself, giving him not only the pleasure of being an active participant in the scientific scene, instead of a passive onlooker, but also the opportunity of showing himself any particular demonstration as many times as he chooses. As one young enthusiast put it: "If I don't understand it the first time, I can do it over again for myself until I do, without having to ask anybody to show me and have them think I was dumb."

As its permanent background, then, the museum has a series of eight main divisions embracing variously the fields of housing, textiles, food, communications, transportation, machinery, power and electrical science and technology. In

THE BUILDING OF MODEL HOUSES.



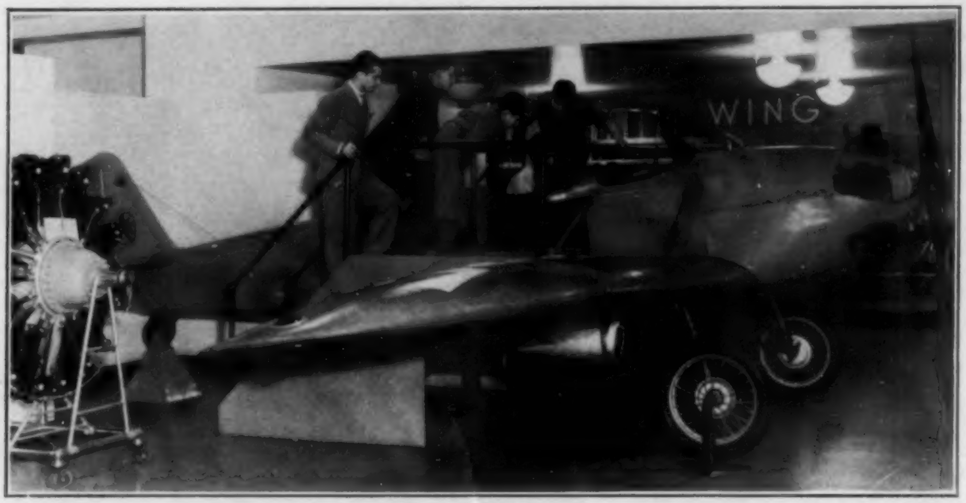
THE TRANSPARENT WOMAN

AN ELECTRIC SYSTEM ILLUMINATES EACH ORGAN IN ROTATION AS THE LECTURER EXPLAINS ITS FUNCTION.

each of these, it purposes to show chronological scientific development from early times to the present, and against them are presented, from time to time, in special exhibit and dramatized demonstration, those significant achievements which have raised man from ignorant savage to informed and cultured world citizen, from primitive fear of natural forces to intelligent understanding and control of them, and his way of living from crudest discomfort to the last refinement of efficiency and ease.

In the housing division, the visitor may study the historical sequence of mankind's ideas of shelter, from the first crude dwellings made from tree branches and leaves to the glass and chromium steel of the ultra-modernist. Supplemented by current special exhibits, the housing section as it stands at the moment presents a pageant of human living from the angle of the historian, the builder, the architect, the city planner, the economist, the interior decorator and the home owner.

On the historical side, there are two exhibits: One, a series of small models showing typical dwellings in different parts of the world from that of the lake dweller to the modern suburban resident, and the other, an elaborate presentation of American housing, beginning with an Indian long house and carrying through successive periods to the present era of compact city apartment and comfortable country residence. A separate exhibit comprises a number of model houses designed by outstanding modern architects, whose chief business is the planning of skyscrapers, while still another of the units of this comprehensive housing panorama offers eight miniature rooms, built and decorated by an interior decorator in period style, true down to the last detail of tiny chair or objet d'art. In a side room just off the housing section, an exhibit of unique models pre-



THE DEMONSTRATION AIRPLANE IN THE AVIATION DIVISION.

pared by WPA workers shows the problems which housing experts have faced, solved and are still wrestling with in American cities.

In the textile field, full-sized models and actual working machines demonstrate the development of spinning and weaving, showing the manufacture of rayon, together with a continuous moving picture, and demonstrating the manufacture of rare and expensive specialty fabrics derived from animals inhabiting the mountainous regions of South America, Tibet and other countries.

The food section offers, against a historical background of plowing methods, demonstrations of such modern processes as sugar refining, milling, mechanical refrigeration in industry and in the home, milk pasteurization and the like. A special exhibit was a model explaining the government's soil conservation program, consisting of a representative stretch of farming country, with sections marked off to illustrate the particular method applied to each type of land, whether pasture, woodland or field.

The history of communication from sign language to radio, with various working instruments which the visitor may operate at will, is told in the communications division. A favorite instructive plaything in this part of the museum is the dial telephone, set beside a working model of a central station, which, as one dials a number, goes into action and shows just what happens during the process of making a telephone call. Another prime favorite is the model of the prow of a ship with a tiny wireless antenna, which may be maneuvered by means of a knob to pick up signals sent out by miniature lighthouses flashing in the distance.

The transportation division, consisting of four sections devoted respectively to highway, railroad, marine and air travel, covers the story of historical development in these important departments, largely in colorful scale models of horse-drawn vehicles, ships, locomotives and airplanes, many of them springing into action when a button is touched. A genuine life-sized covered wagon in the highway transportation section, and, in the marine section, a large ship model which may be raised and lowered in drydock, are two exhibits which particularly intrigue visitors.

Just how appealing the subject of aviation is to the amateur has been demonstrated at the museum in the widespread interest aroused by the placing on exhibition of a Taylor Cub plane, the most popular type of plane for amateur flying. At intervals during the hours when the museum was open to the public, a young and enthusiastic lecturer stood by the plane and talked informally on "Why an Airplane Flies." In accordance with its regular practice of announcing the various demonstrations, the talk was heralded over the museum's loudspeaker system just before it began, and the rush for the corner where the plane stood, as well as the size of the crowd which assembled to hear the talk, both gave ample witness to the fact that this was one of the most popular features of the museum program.

In the machine division, original machines and replicas, both historical and modern, demonstrate the speed and efficiency with which things are done in the mechanical world to-day. Striking a note that touches the casual visitor even more closely, a special exhibit of machines used in the business world is shown, and the passer-by may stop and experiment as much as he pleases with electrical machines that count and add and sort and tabulate and write far more casually and accurately than any human.

Then there is the power division, where numerous types of engines, turbines, models and dioramas trace the steps that have been taken through the years in harnessing water, steam and electricity for the benefit of man. Most of these may be put through their paces by means of push buttons or lever.

The principles of electrical science and technology, abstruse as they are to the average person, become intelligible to the lay mind when they are explained in terms of pulling magnets, jumping balls and various kinds of apparatus that revolve and leap and twist and turn. A host of such things, demonstrating such mysteries as terrestrial magnetism, alternating and direct current and many

A LECTURER DEMONSTRATING MINIATURE HYDRO-ELECTRIC POWER PLANT.

AN EXHIBIT IN THE ELECTRO-TECHNOLOGY DIVISION

others, are permanent exhibits in the museum's electro-technology section, while the current attraction of a temporary character is the smallest hydro-electric power plant in the world, generating electricity right out in the open for all to see. Hydro-electrical unit, transmission lines, sub-stations, a miniature railroad and two toy-sized industrial plants that run by the power generated, tell the story in simple, vivid form, and several times a day a lecturer is on hand to put the whole thing in motion and explain it in popular terms.

In addition to those already mentioned, the museum recently held four major exhibitions and demonstrations which have aroused wide interest. Of these, the now nationally famous "transparent woman" probably attracted the most attention, for the simple reason that it is the first of its kind in the world, and was shown at the museum for the first time anywhere. Built on a human skeleton and enclosed in a transparent "skin" of a substance known as cellhorn, every organ of the female body is shown, together with the circulatory system. By an ingenious electrical system, each organ is illuminated in rotation as a lecturer points it out and explains its function, giving to many among the audience their first really scientific conception of how the human body is actually constructed.

Also receiving notable popular attention was the fire prevention exhibit, in which the eight most common fire hazards were demonstrated and explained by the extremely dramatic method of starting a certain conflagration or causing an explosion in miniature form under perfectly controlled conditions. Electrical fires, so-called dust explosions, fires caused by vaporous chemicals and spontaneous ignition fires were all illustrated in spectacular manner, accompanied by a running talk which told why this happens when that is done, and how to avoid it.

The Edison Industries Exhibition, in which the major achievements of the great inventor are shown in historical models, original machines, replicas, dioramas and many other forms, together with exhibits representative of the numerous important industries which have grown out of Edison's original work, has been at the museum for almost a year. The attention which the public has paid to this feature indicates clearly that there is an abiding interest in the type of exhibit which shows a great man and his work.

The invention of Polaroid, a material which puts the polarization of light under practical control and makes it an understandable and usable tool in everyday life, has been called by no less a person than Dr. R. W. Wood, of the Johns Hopkins University, the most significant invention in the field of optics within the past generation. The story of Polaroid, together with demonstrations of its numerous

practical applications, was given to the public for the first time in a series of exhibits showing such exciting things as non-glare headlights, three-dimensional motion pictures in natural colors, new achievements in amateur and professional photography and microscopy, and glasses that, by the control of light glare, reveal to the wearer hitherto hidden beauties of color and effect both outdoors and in. A lecture-demonstration given at intervals made it possible to view with clearer understanding and greater enjoyment the different phases of the subject presented in the various exhibits.

In January, the popular automobile driving clinic, which drew thousands of people to the museum throughout the past spring and summer, returned for another period. During its previous stay, an average of 150 people a day—the capacity use of the equipment—were tested for color blindness, for the quickness of their reaction in braking a car; for their susceptibility to headlight glare; for their ability at the steering wheel in holding the car to the proper driving lane on the highway and for their skill in judging the relative speeds of moving vehicles.

As the schedule of lectures, demonstrations and special exhibits is now arranged, it is not unusual for visitors to remain in the museum for the best part of an entire day, in order that nothing may be missed. Nor do any seem to find the minutes dragging as they wait for the beginning of some special feature. On the contrary, they do well if they manage to see all that there is to be seen during the intervals between the demonstrations.

THE ZOETROPE

A MODEL OF THE TOY WHICH LED EDISON TO THE INVENTION OF MOVING PICTURES.

In the first ten months after the Museum of Science and Industry opened its headquarters in Rockefeller Center, nearly half a million people viewed its exhibits, with the attendance mark moving steadily upward, ample evidence that here, scientifically speaking, is the answer to what the layman wants to know.

CONSERVATION AND USE OF FORESTS IN THE SOUTHWEST

By G. A. PEARSON

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EXTENSIVE land conservation in the United States had its origin in forestry more than 40 years ago. Through the forestry profession, the doctrine of land management was transplanted to this country from Europe, where for centuries forests, including timber, soil, water and wild life, have been managed for continuous production. The first national forests, or forest reserves, as they were then called, were withdrawn from the public domain in 1891. In 1897 Congress authorized the President to provide for the regulated utilization of reserved forest lands. It was not until several years later that effective forestry practice began to take form. During the administration of President Theodore Roosevelt, the "forest reserves" were renamed "national forests" and their area was greatly extended. By 1934 the national-forest area in the United States, including Alaska and Puerto Rico, had grown to 162 million acres, nearly one eighth of which was in Arizona and New Mexico. Besides the high forests or saw timber, this domain includes large areas of low-growing woodland species and areas occupied by brush and grass. Only forests of the first-named class are discussed in this paper, because it is here that management has made most progress and promises the greatest returns.

THE TIMBERLANDS OF ARIZONA AND NEW MEXICO

Of the nearly 11 million acres classed as saw-timber land in Arizona and New Mexico, 86 per cent. is in public ownership. National forests contain 66 per cent., Indian reservations 17 per cent., national parks and state lands account for about 3 per cent. and 14 per cent. is in private ownership.

Destructive agencies have dealt less harshly with the forests in the Southwest than in most other regions. Vast areas of pine, fir and spruce remain in essentially their primeval state (Fig. 1). About one fifth of the commercial saw-timber lands have been logged, but a large portion of this cutting has taken place under more or less conservative methods. Fires that burned whole mountain sides in the early days are almost a thing of the past, and most of the old burns are gradually restocking under protection. Although examples of devastation by cutting and fire are not lacking it is estimated that less than 10 per cent. of the timberlands have suffered to the extent that planting is necessary to reforest them. Timberlands as a class are not a wasted resource calling for expensive rehabilitation. Exceptions to the rule are almost invariably lands which have not had the benefit of forest management. A better picture would be presented to-day if the early pioneers had been more forestry minded; but, on the other hand, what would the picture be if forest management had been postponed until the present time?

FORESTRY A PUBLIC FUNCTION

Timber-growing as a commercial enterprise generally has little appeal to private capital in the Southwest because of

[1] Maintained at Tucson, Arizona, by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of Arizona.

the long time required to realize returns on such an investment. Individual owners prefer or are forced by financial circumstances to convert marketable timber into cash as quickly as possible without regard for permanent production. Quite commonly, the first cutting on private lands leaves enough immature trees to preserve some semblance of a forest but, at most, the remnants will be spared only a few decades. Under the pressure of taxes and interest, the individual owner usually has no other choice. When timber exploitation is complete the land more than likely becomes a liability to both the owner and the public. The only practical solution is acquisition by public agencies before devastation goes beyond control. Federal and state governments are able to forego immediate income for sustained returns and, besides, public interest takes into account important indirect values such as water, recreation and wildlife which rarely bring a financial return to the individual owner.

A growing public appreciation of esthetic qualities in forests often assumes expression in a protest against commercial cutting. The forester's answer is that beauty and utility can be combined to the advantage of both. Actually, Arizona and New Mexico have thousands if not millions of acres of timber which, on account of location or topography, probably can never be economically logged. Under public ownership, such forests will be managed as watersheds or recreational areas, or with the purpose of restoring and preserving primeval conditions. But as long as timber is needed for human use, accessible forests will be called upon to supply that need.

Timber Management in the National Forests

Effective timber management under public ownership is exemplified in the national forests. The administrative policy of the Forest Service has recognized from the outset that forestry involves not only conservation but also utilization. A lumber industry and a livestock industry, both dependent upon the national forests, furnish a livelihood in whole or in part to thousands of people. If at times exploitation has appeared to profit at the expense of conservation, human and social aspects have usually stood in the background. In the cut-

FIG. 1. VAST AREAS OF PINE, SPRUCE AND FIR

REMAIN IN ESSENTIALLY THEIR PRIMEVAL STATE. (UPPER) PONDEROSA PINE (*Pinus ponderosa*) AND (LOWER) ENGELMANN SPRUCE (*Picea engelmanni*) AND CORKBARK FIR (*Abies arizonica*). COCONINO NATIONAL FOREST, ARIZONA.

FIG. 2. CUTOVER PINE FORESTS
(UPPER) UNREGULATED CUTTING ABOUT 50 YEARS AGO, FOLLOWED BY FIRE AND IMPROPER GRAZING, RESULTED IN POOR NATURAL REGENERATION AND TIMBER GROWTH. (LOWER) NATIONAL FOREST CUTTING 27 YEARS OLD; NATURAL RESTOCKING IS ALMOST COMPLETE AND THE TREES LEFT UNCUT ARE GROWING AT A RATE THAT WILL PROVIDE A SECOND HARVEST EQUAL TO THE FIRST ABOUT 30 YEARS HENCE.

ting of national-forest timber in Arizona and New Mexico, no concessions have been made that would seriously jeopardize regeneration and continuous production of the forest. If the reader's observations seem to contradict this statement, account should be taken of the fact that extensive areas within the national forests were cut, or private timber rights acquired before the lands were incorporated in the national forests. Conspicuous examples are the land grants of alternate sections ceded to the railroads before the national forests were created, the timber sold to lumbermen and the land itself reverting to the government after logging by private interests. Control of grazing has been more difficult and generally less effective than control of timber cutting on national-forest lands, but substantial progress in decreasing damage to the forests by live stock has been made during the last decade.

Essential steps in timber management are protection, orderly harvesting, restocking and improvement of young stands.

Protection: Protection implies, first and last, security against fire. The pine forests of the Southwest are less subject to crown fires than are the dense forests of the Pacific Coast and the Northwest; but a ground fire once in 20 years may destroy all young trees and thus prevent restocking. Fires in tall grass or in logging "slash" (the debris left after cutting), are especially destructive. Fifteen years ago, slash fires of a thousand acres or more were all too common, but now they seldom attain a fourth that size. Marked improvement in fire protection has resulted from development of transportation and communication systems, including roads, motor equipment and telephone lines. No less important has been the progress in methods of fire detection and in the training of fire-fighting personnel, which have gone steadily forward over a quarter century. It must be expected, however, that as increased production makes available greater quantities of fuel in the form of young trees, leaf litter and grass, fires will become increasingly difficult to control.

Certain biological agencies may cause

FIG. 3. "TIMBER STAND IMPROVEMENT"

IN THE COCONINO NATIONAL FOREST. THRIFTY TREES OF DESIRABLE FORM ARE FREED OF COMPETITION BY REMOVING INFERIOR NEIGHBORS, AND THE TRUNKS ARE PRUNED OF LIMBS TO A HEIGHT OF ABOUT 17 FEET IN ORDER TO PRODUCE LUMBER FREE OF KNOTS. ONE OF THESE FAVORED TREES IS INDICATED BY A WHITE CROSS. BRANCHES ARE SCATTERED IN THE LARGER OPEN SPACES IN ORDER TO PROTECT THE SOIL.

damage that calls for special protective measures. Domestic live stock browse tree seedlings; porcupines kill seedlings and damage trees of all ages by gnawing the bark; bark beetles may destroy entire stands, and fungus diseases may kill the stems and foliage or cause decay of the wood. At the present time several CCC camps are employed in an effort to stamp out a new pine disease known as "twig blight."

Orderly Harvesting: One of the oldest principles in forestry is the sustained yield. The term is self-explanatory: it means that cutting is so regulated that over a long period it will not exceed the rate of growth, and that production will be sustained or increased as the years go by. Thus far, the rate of cutting in the national forests of the Southwest has been less than the rate of growth. This can not be said of all classes of owner-

ship, but if good forestry is henceforth practiced on all the forest lands they are capable of supplying the raw material for a much enlarged lumber industry. Overcutting, even if good fortune should bring about natural regeneration, results in deferring the next harvest by anywhere from 100 to 200 years; conservative cutting, on the other hand, permits successive harvests at intervals of 60 years or less (Fig. 2).

To regulate cutting on a plan of sustained yield requires information which in this region has taken many years to acquire. The forests of the Southwest usually contain several generations or age-classes, ranging from mature veterans down to the sapling stage. Records of some 50,000 trees of different ages and sizes on typical areas in different localities over a period of 20 or more years have determined the rate of growth and mortality. Yield tables are being prepared from which the size of the timber crop can be predicted far into the future with greater accuracy than the Department of Agriculture estimates currently the annual crops of corn, wheat and cotton.

Natural Restocking: The most vital process in timber management is regeneration or the replacement of trees which have been harvested or have died from other causes. For the most part, this must be accomplished by natural means —by natural seedfall virtually entrusted to the elements. During many years after the national forests were created, natural restocking failed to follow cutting on the largest logging projects in the Southwest. Rigid fire protection and provision for natural dissemination of seed proved to be without avail. The Southwest became known in forestry circles as a region where forests are doomed to decline through failure of regeneration. Lacking knowledge as to what actually took place, it became convenient to place the blame on the climate. Research discovered that the major trouble lay in grazing, and later it was found through extensive practice that an effective remedy is available in control of numbers of stock and seasons of grazing rather than in total exclusion. A further discovery is that grazing under a forester's direction can be employed to aid tree reproduction by control of competing vegetation. Many facts have been gathered on the relation between seed production, climate, soil, plant competition and the reproduction of pine. Nature is kind indeed if she permits 5 per cent. of the seeds which mature to germinate and grow to the sapling stage; and yet, this order is not unusual because nature is wasteful. Despite a multitude of adverse agencies, many tree seedlings usually gain a foothold in the course of two or three decades. For the purpose of this discussion it is sufficient to say that, so far as regeneration of ponderosa pine is concerned, the climate is really more favorable in the Southwest than in most other regions where this species occurs, and that if man will take advantage of factors within his control, timber crops can be harvested with reasonable assurance that the forests will remain a perpetual source of public wealth.

Care of Young Stands: Recent efforts have turned toward improving the yield of timber crops in the national forests. Not only can the annual rate of volume growth be increased, but the quality of wood products can be improved. Lumber, like meat, fruit and other commodities, is sold according to grade. It is estimated that our forests can be made to yield three or four times their present monetary returns by growing more and better trees per acre. During the last three years, advantage has been taken of employment relief measures by subjecting thousands of acres to "timber stand improvement," which consists essentially in removing inferior trees and encouraging the growth of desirable ones

FIG. 4. AN OLD PINE FOREST

IN WHICH THE LARGER SPACES BETWEEN TREE GROUPS ARE OCCUPIED BY SEEDLINGS AND SAPLINGS, OR "ADVANCE REPRODUCTION." WHEN SUCH A FOREST IS LOGGED UNDER ADEQUATE SAFEGUARDS, THE REMAINING YOUNG TREES RESPOND VIGOROUSLY TO THE STIMULUS OF INCREASED SUNLIGHT AND SOIL MOISTURE. THE LARGE TREE IN THE MIDDLE FOREGROUND IS DEAD.

by thinning and pruning (Fig. 3). Of the various classes of work adapted to employment of the Civilian Conservation Corps, few hold promise of self-liquidation in the same measure as timber stand improvement.

Economic Aspects of Land Conservation

It is axiomatic that whatever is conserved should be worth conserving. The Southwest contains vast areas whose capacity for growing crops of any kind will always be low. The submarginal land problem is not confined to farm lands, but may apply as well to forest and range. Nor can expensive rehabilitation measures always be justified by indirect values such as water and recreation. Water for domestic use is a priceless asset, but irrigation has economic limitations that must be recognized. In thinly populated regions there is also a limit to the acreage that can be maintained at public expense primarily in the interest of recreation. The time will come when public lands must not only cease to impose a tax burden but must become a source of revenue to the nation.

Of the various types of "wild" land in the Southwest, forests offer perhaps the greatest possibilities of economic self-support. A relatively small percentage of the commercial timber area has lost its productive capacity. In public hands, timber is capable of yielding a much

FIG. 5. A MANY-AGED PINE FOREST

MADE UP OF VETERANS OVER 200 YEARS OLD, YOUNGER GROUPS OF MERCHANTABLE SIZE ABOUT 150 YEARS OLD, STILL YOUNGER GROUPS OF ABOUT 100 YEARS, "POLE" GROUPS OF 50 TO 60 YEARS, SAPLING GROUPS OF 1914 AND 1919 ORIGIN, AND FINALLY SEEDLINGS OF 1928 GERMINATION. IN THE NEXT CUTTING NEARLY ALL THE VETERANS AND A FEW OF THE 150-YEAR CLASS WILL BE REMOVED, LEAVING AN ABUNDANCE OF YOUNGER TREES TO MAINTAIN THE FOREST CANOPY AND PROVIDE FUTURE CROPS. FORT VALLEY EXPERIMENTAL FOREST, U. S. FOREST SERVICE.

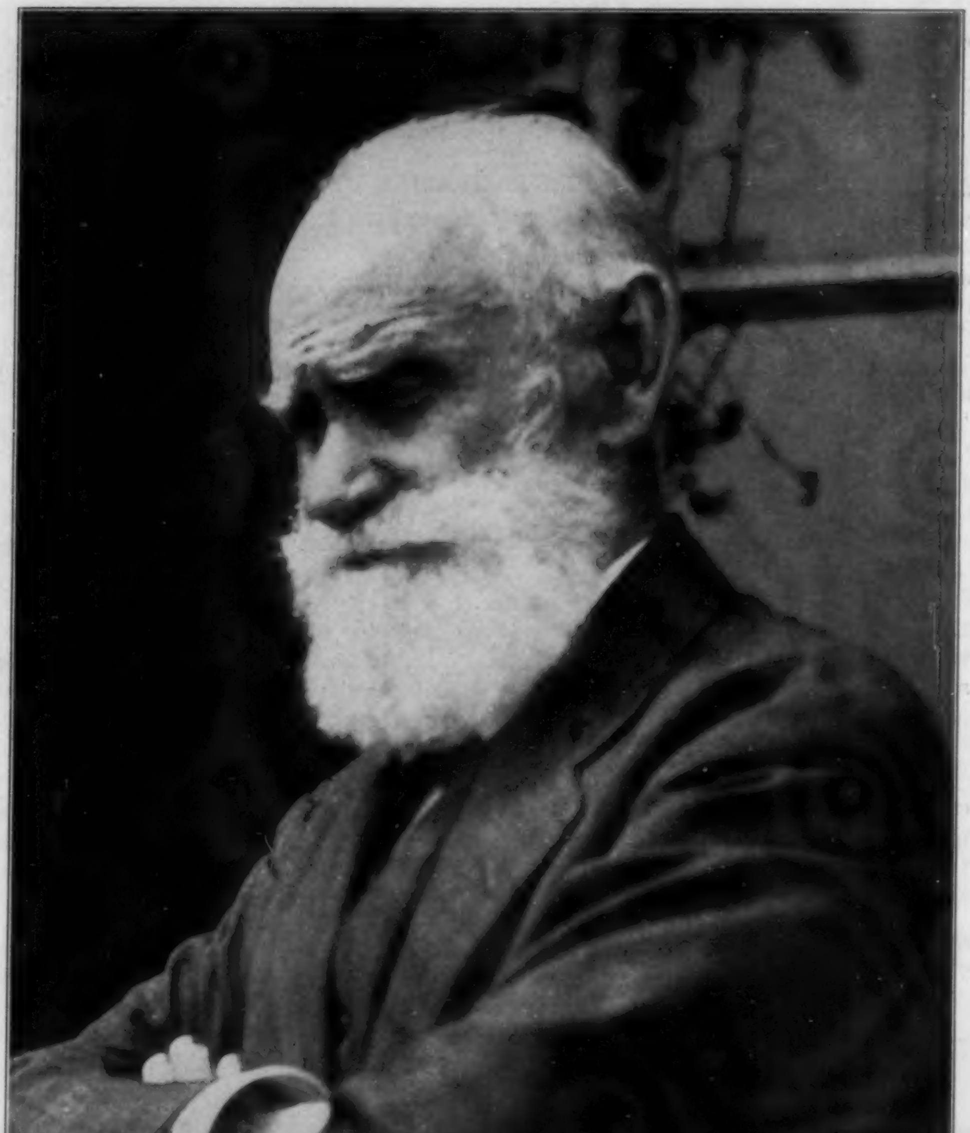
higher monetary return than most other uncultivated crops. This is true whether the comparison applies to direct sale of the raw materials or to public benefits in the form of employment and local business incident to conversion of raw materials into usable products.

The high watershed values ascribed to forests need not suffer from cutting under good timber management. From the pine mesas to alpine heights the forests of the Southwest occupy the zones of heaviest precipitation, especially snowfall, that contributes most to sustained stream-flow. A forester's conception of an ideal watershed is a forest whose canopy is open enough to admit a high proportion of the precipitation, but dense enough to form a continuous carpet of leaf litter. In such a forest the soil is more porous and permeable to water than either grassland or cultivated fields. The best if not the largest contribution of a forest to water supplies is by percolation through underground channels. Under the type of timber management which is now in process of development, the presence of many age-classes will make it possible to remove mature timber without exposing much of the soil area, and thus the watershed functions will be met as fully under regulated cutting as in the virgin forest (Figs. 4 and 5).

Under advanced forms of management the harvesting of timber crops does not permanently mar the beauty of the forests. True, logging operations do leave quantities of unsightly debris, but this largely disappears in 15 or 20 years, or becomes screened by young trees. A condition which contributes to heavy cutting and the volume of debris is a preponderance of old and defective trees. Timber management is gradually converting over-mature forests into stands in which the younger generations predominate. When this transition has been brought about, logging scars will be less conspicuous and more quickly healed than at present. The public may well demand that forests be kept beautiful; but, on the other hand, it must recognize that the removal of mature trees is in accord with nature's scheme to preserve the biological vitality of the forest and that utilization of the mature crop provides revenue with which to meet the cost of protection and administration.

Forests of the Future

Conversion of untended or unwisely exploited forests into a high type of managed forest is a slow process. Thirty years of organized forest management in the Southwest has made a substantial beginning, but only that. Noteworthy progress has been achieved in natural regeneration, which is the first requirement, regardless of the object of management. Accomplishments in this direction are by no means complete. Other steps are in the direction of higher quality production. But not all forests will be managed for maximum timber crops; in fact, extensive areas probably will never hear the sound of the woodsman's saw and axe. For the most part recreational areas will be in locations from which logs can not be economically transported, and why not, now that automobile roads have made the most remote forest sections accessible to pleasure seekers and nature lovers? Forests managed primarily for timber production will be none the less valuable for other legitimate uses, subject to the doctrine of greatest good to the greatest numbers. The principles of sustained yield and selective cutting automatically avoid the extremes of uniformly old or young stands, and instead will foster a gradual transition toward many-aged forests in which trees of all ages, ranging from mature veterans to tender seedlings, intermingle in groupwise arrangement.



IVAN PETROVICH PAVLOV

THE GREAT TEACHER AND MASTER OF SCIENCE

IN MEMORY OF PROFESSOR IVAN PETROVICH PAVLOV

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PROFESSOR I. P. PAVLOV was a rare combination of genius and research worker, of an exceptionally talented experimenter and great teacher. Possessing a lively intelligent mind, a passionate striving towards knowledge, a strong will and unusual steadfastness in pursuing his aims, Pavlov was endowed by nature with gifts which, in conjunction with his constant effort for self-improvement and his untiring labor, became the source of his creative energy, great ideas and his immortal fame. For more than sixty years he was a tireless and fearless searcher for truth.

During this long period of work marked by singleness of aim and constant striving for the confirmation of new ideas, tormenting doubts and the joys of achievement, those characteristics were crystallized in Pavlov which are inherent in a great investigator who creates a new epoch in the history of science.

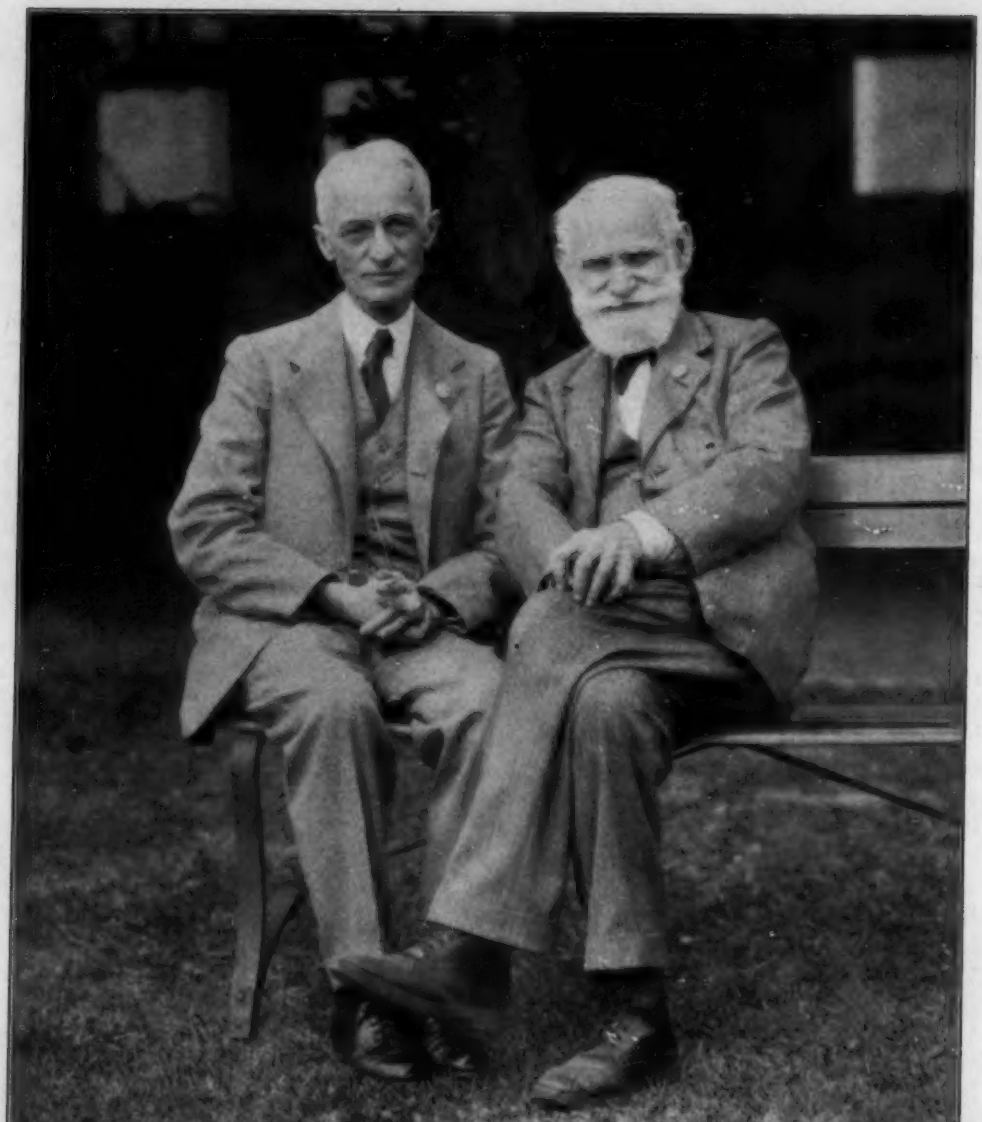
Therefore, while studying the exceedingly rich scientific heritage left by Pavlov, it is necessary to study, at the same time, his manner of scientific work and his personality as a research worker and teacher.

The author of this essay does not take it upon himself to give a complete analysis of Pavlov's genius and his methods of work. Such an analysis would require many years devoted to the most thoroughgoing study from this point of view of all Pavlov's work; it would be necessary to follow step by step the history of the birth of his great discoveries and ideas, to reveal the entire process which helped to shape his personality against a wide social background. This will be the task of future investigators. The present essay is only the first experiment in this direction—an attempt to present the living image of Pavlov as a master of science and a great teacher. The material on which this essay is based are the impressions and experience accumulated by the author during fifteen years of acquaintance and work with Pavlov. In dealing with Pavlov's unified nature it is difficult to divide the teacher from the truth seeker, the manner of passing on knowledge from the manner of accumulating it. It is quite inevitable that in exposition the boundary between these two characteristics will be practically indiscernible.

"STUDY, COMPARE AND ACCUMULATE FACTS"

Pavlov acquired his knowledge not from books but from the fountain-head of life: in the laboratory, in nature's own factory, by sitting at the pedestal of facts.

In 1873 he crossed the threshold of Zion's laboratory for the first time and from then until the very end of his life he never ceased experimenting. The laboratory was not only his workshop but also his great school. Pavlov attached great importance to facts in scientific investigation. "Study, compare and accumulate facts. As perfect as is the structure of a bird's wing, the bird would never be able to fly if its wings were not supported by air. Facts are the air of the scientist; without them you would never be able to fly. Without them your theories are useless efforts,"—thus wrote



PAVLOV AT THE AGE OF EIGHTY YEARS WITH DR. HARVEY CUSHING.
THE PHOTOGRAPH WAS TAKEN ON THE CAMPUS OF HARVARD MEDICAL SCHOOL IN 1929 AT THE XIITH INTERNATIONAL PHYSIOLOGICAL CONGRESS.

Pavlov in his last letter to the Soviet youth who have dedicated themselves to science. This he always repeated to his laboratory students.

But a fact gains force and significance only when it is accurately described and checked. In that case the fact is indisputable and controls the investigator. Woe to the investigator if he ignores those facts which do not fit into the frame of his conception or destroy an *a priori* theory. A fact contains within itself forces which act in contradiction to each other: it is constructive and at the same time destructive. This is a *primum mobile* on which progress towards truth depends. Discoveries are born precisely there, where facts which form exceptions to the rules are investigated. These deviations from the usual order demand special study.

However, the mere accumulation of facts without a general idea in mind, without a plan, is a useless occupation. Pavlov taught: ". . . try not to stop only at the surface of a fact. Don't become an archive of facts. Try to penetrate the secret of their appearance. Obstinately seek the laws governing them." The aim toward which facts are accumulated is precisely this last point—"the discovery of the laws governing facts." Thus a fact is not an end in itself, but only the means towards mastery of the general laws of nature.

How should facts be accumulated? "When you have no ideas you can't see the facts," Pavlov often reiterated when his attention, during an experiment, was fixed by some important phenomenon which repeatedly cropped up and was evident to the eye for a long period of time but nevertheless remained unnoticed. New facts, new phenomena must be illuminated by ideas which correlate them. Only under such conditions can investigative thoughts really bear fruit.

"Observation, Observation and Observation"

However, in order to observe new facts it is necessary to know how to observe them. Pavlov attached primary importance to keenness of observation as the main ability required by an experimenter. Upon his suggestion the main building of the biological station in Koltushy has inscribed on it the simple words: "Observation and observation." Pavlov himself possessed this quality to perfection; in him it was habitual. In the most difficult moments of an investigation, when the data obtained by an experimenter did not lend themselves to analysis, Pavlov himself took up the experiment. And almost always the puzzling phenomena were explained. If the matter proved more complicated, supplementary experiments were performed; new collaborators were drawn into the investigation. Pavlov stubbornly persisted until he found the cause of this new phenomenon. Very often new ideas and themes were engendered in this process. Pavlov always recalled: "The very best themes, the most profound questions were conceived during an experiment, while working." Observational keenness helped Pavlov to conquer a considerable difficulty which he encountered while still in the period of the study of the physiology of digestion. This incident is so instructive that I give it in Pavlov's own words.[1] Due to the corrosive action of the pancreatic juice, it was impossible to obtain a chronic fistula in the pancreas.

> One of the dogs operated on by our method began, some ten to fifteen days after the operation, to be affected by the corrosive action of the juice. Our methods did not completely attain the end sought. The dog was kept chained in the laboratory. It so happened that one morning, to our sorrow, a heap of plaster broken from the wall was found near the dog, which usually was very quiet. The dog, still chained, was moved to another part of the room. The following morning the same story had been repeated! Again the wall had been ruined. At the same time it was noticed that the dog's abdomen was dry and that the inflammation of the skin had diminished. Only then we finally guessed what was the matter. When we made the dog a bed

[1] I. P. Pavlov, "Lecture on the Function of the Chief Digestive Glands." Third edition (Russian), p. 18, 1924.

of sand, the animal ceased scratching at the wall and slumber no longer harmed him. We (Dr. Kuvshinsky and I) gratefully recognized that by its intelligence the animal helped not only itself but also us.

This remarkable incident impressed Pavlov so profoundly that he immortalized it on the bas-relief of the pedestal of a monument to the "unknown dog," set up in front of the laboratory.

Pavlov often used himself as an object of observation—especially when, during an illness, his usual activity was naturally restricted. In 1927, in the seventy-eighth year of his life, he underwent a serious operation for the removal of gall-stones. A few months after the operation symptoms of palpitation of the heart appeared. For a time Pavlov analyzed in detail the cause of these cardiac disorders. Special experiments on Pavlov were performed jointly with M. K. Petrova, until, finally, the explanation was found, and recorded by M. K. Petrova in "Post-operative Cardiac Neurosis, Partly Analyzed by the Patient-physiologist I. P. P. Himself," which was published in 1930.

The most characteristic instance of Pavlov's observational keenness is related to his study of the changes brought about in his own organism by increasing age. In connection with the study of the lability and inertia of the nervous processes with which his laboratory was then (1933) engaged, Pavlov often spoke during laboratory discussions of the changes caused by age in the higher nervous activity, and in illustration related the results of his observations upon himself.

You see, although age can not be considered pleasant—it brings many shortcomings with it—still, I want to draw some benefit from it. And obviously, in connection with conditioned reflexes and the study of the nervous system, I constantly watch what age is bringing me. It is interesting that the same thing is happening to me that happens to all old men. That is natural. And you know that one of the first effects of age is loss of memory regarding impressions which were recently fresh.

Then the physiological explanation follows: ". . . age is first of all expressed in the weakening of the reactions of the cortex of the cerebral hemisphere. . . ." It is possible to cite a great number of incidents showing that no matter in what surroundings or conditions Pavlov found himself, the experimenter and observer in him was always evident. A keen observation became second nature to him. Even a few hours before his death Pavlov watched with alarm the work of his own brain. And when he felt that he was beginning to lose control over his thoughts, he asked for a neuropathologist in order to analyze with him the nature of the disorders of his brain. The neuropathologist gave Pavlov a satisfactory explanation and then he felt reassured, fell asleep and, a few hours later, died.

Pavlov was strict towards himself and strictly demanded of his students correct accumulation of facts.

"The A. B. C.'s of Science"

Facts must be correlated, inspired by a unified idea. Where does this idea come from? Confused thinking only leads to unnecessary, wordy webs. Scientific research demands sequence first of all—consistency in the accumulation of knowledge. "Learn the a. b. c.'s of science before ascending its heights. Never reach for the next step before having mastered the preceding one." Such was Pavlov's counsel to the youth striving towards scientific activity. In this respect Pavlov himself was the best example. Gifted by nature with many weapons for mastering and directing her, Pavlov armed himself, in addition, with knowledge which he acquired by stubborn and persistent work. Thus armed he became a person dangerous to nature.

Without the acquisition of positive knowledge scientific work is impossible. As stated above, Pavlov learned, not so much from books, as directly in the laboratory. This was not a passive contemplation of natural phenomena passing before the eyes of the experimenter, but active observation accompanied by intense thinking. The experiment was

strictly planned in all its details and was subordinated to the aims of the experimenter. Nothing escaped the vigilance of Pavlov. Always tense and concentrated on his work during an experiment, he resembled a hunter tracking his game.

"A physiological experiment," said Pavlov, "may depend upon a mass of petty conditions and unexpected occurrences which should be noticed during the experiment, otherwise our material loses its real purport."

Pavlov had illustrious teachers, who were outstanding physiologists—Zion, Ludwig, Heidenhain. They were founders of a new division of physiology. However, Pavlov's studies were not limited to the laboratories of the best physiologists of his time. He also studied in the clinics, working as the director of a laboratory in the clinic of the renowned Botkin for several years. Here Pavlov was faced with the task of finding solutions to new questions raised by practical physiology. Working intensely from morning until late at night, Pavlov mastered new problems, elaborated new methods and acquired new knowledge. In this work first arose the idea of the mutual benefit existing in an alliance between experimental methods and the clinic, the rôle of practical experience in the discovery of biological laws.

For five years Pavlov held the chair of pharmacology in the Military Medical Academy. In this period, Pavlov, being a reader in physiology, not only mastered a subject new to him but also breathed a stream of new life both into the method of pharmacological investigation and the teaching of pharmacology. Knowledge of pharmacology was of great service to him later when he applied it to the study of the higher nervous activity.

Pavlov had an excellent knowledge of the literature of his subject. A strict schedule for a working day included a special period set aside for the reading of magazines and books. He read slowly and re-read one and the same article or book two or three times. While reading he was often aggravated when he met a bare assertion or unverified fact. He argued and defended himself vehemently when his work was criticized. And, finally, he was overjoyed and triumphant if his facts were confirmed by other investigators.

Pavlov studied all his life. He was not afraid to begin from the a. b. c.'s. In 1918, when he was 69 years old, Pavlov, becoming interested in some mental disorders, went every Sunday to his friend Dr. Timofeyev to study at the Udelnaya Psychiatric Hospital. Many years later, when Pavlov was already eighty years old, he began to study psychology. Like a young student he started to study the classical text-books on psychology, read a great number of psychological articles and nevertheless, with all his erudition, modestly considered himself an empirical-psychologist.

Thus, for more than fifty years Pavlov constantly amassed more knowledge. This explains the boundless extent of his interests.

"Complexities are Conquered by Science Only Gradually and in Separate Parts"

Even a tremendous store of knowledge and the accumulation of a great quantity of facts is still insufficient for true scientific creation—the birth of ideas. The investigator is ever confronted with the endless complexity of phenomena, their varied interactions and complex causal dependence. How should one separate into its component parts and analyze all this complexity? How can the dismembered parts be put together again?

Pavlov showed how science attacks this difficult problem. In 1902 standing on the threshold of an enormous uninvestigated field, embarking upon an objective physiological study of the work of the brain, he found himself invading the forbidden zone called "spiritual life," a zone which, until the advent of Pavlov, was wholly ruled by psychology. Pavlov clearly understood the danger of this

audacious attempt. He knew that he would meet with desperate resistance on the part of both nature and man. "One should not," wrote Pavlov in 1906, "close one's eyes to the fact that the contact of true consistent natural science with the last border of life can not take place without important misunderstandings and opposition. . . ."

Thirty-four years have elapsed since then. The final aim—the full and complete mastery of all the natural laws regulating the function of the brain—is still remote, but the first battle has been conquered, the method has justified itself, the results offer assurance that the road selected is the right one.

"The complex can only be conquered by science by one part at a time and in sudden attacks, but gradually becomes more and more embraced by it." In this manner Pavlov encouraged those who stopped from indecision before the complexity of a phenomenon. To embrace all at once is impossible. One must limit oneself. One must be able to concentrate one's thoughts exclusively on a single problem. Pavlov revealed the unusual advantage of this method. For ten years he was engaged in the study of the physiology of digestion, devoting all his own energies and the energies of his coworkers to this investigation. All other problems not related to digestion were excluded from the laboratory. More than thirty years he devoted to the physiology of the brain, categorically resisting all distractions from the main problem. Persistent cogitation and a strained concentration of thoughts lasted for years. Pavlov knew how to cause his collaborators to think of the same thing with which he was busy. What an iron will is needed for this! How many temptations are met with on the road of an investigator! How difficult it is to restrain oneself, not to be turned aside, when directly within the process of investigation new unstudied fields are revealed, when new questions arise and new conceptions tempt the investigator with promising discoveries. Pavlov never lost himself in such cases. He knew how to counteract temptations himself and how to keep his students from making mistakes. He mastered all subjects in their complete aspects with exceptional penetration and breadth, without dwelling on details. He always saw the final aim before him clearly. "Only when we keep in mind the whole—the normal operation of one or another branch of an organism—can we differentiate without difficulty the accidental from the essential, the artificial from the natural; only then we can easily find new facts and often notice mistakes quickly." This idea guided Pavlov when, from separate, odd analytical data, he elaborated the synthesis of digestion. The entire teaching on the higher nervous system grew from the simple fact of studying the salivary secretions, from the physiology of the salivary glands. The fact of the existence of salivary glands is in itself of small significance. The salivary glands are an organ whose biological importance in the system of an organism is paltry. However, this ability to seize upon basic factors, to note the leading links in a chain made it possible for Pavlov to open a new chapter in physiology—the chapter on the function of the brain. The difficulties met on the road of investigation were many. They were conquered, but sometimes temporary delays occurred, pauses for orientation, for gaining strength by means of verification of that which had already been achieved, for making new plans. Other difficulties were temporarily put aside. That which was postponed was never forgotten—it was retained in Pavlov's unusual memory for future solution in a new manner.

Dangers

Pavlov knew very well the dangers which confront an investigator in his work. He always told his students that it is better to recognize danger than to ignore it. And the first, most important danger lies in the experimenter him-

self: "Usual weakness in thinking processes: stereotyped ideas and the tendency to work with preconceived notions." Stereotyped and preconceived ideas bind the scientific mind, hinder the flight of scientific fantasy. Conventionality as a property of nervous activity was even made the subject of a special study in Pavlov's laboratory.

To break away from conventionality is a difficult task not only for dogs under the condition of laboratory surroundings, but also for a person. The stronger the conventionality, the more difficult it is to get rid of, and the more painful is the rebuilding. And in extreme cases such a breaking away from conventionality is accompanied by a nervous "break down," *i.e.*, by a pathological condition. Conventionality in scientific thought means routine, doctrinairism, deification of authorities, belief in the infallibility of old dogmas. Pavlov was able to demolish old dogmas, to introduce fresh, new and bold ideas into investigative work. His independent mind was subordinated only to facts and experience. Only the striving to learn from experience, not only from his own but from the experience of others made a person equal to his time.

Preconceived ideas are necessary for scientific investigation, but one must be able to reject them. Claude Bernard considered that the preconceived idea is a question addressed to nature. We must coolly listen to the answer, and then, having received it no matter what it may be, we must dismiss our question.

During the process of work many guesses and theories arise in the investigator's mind. A large number of them are annihilated by the criticism to which they are subject and only a very small number of suppositions and hopes are materialized. This cleansing work frees science from false views. Not many men possess the ability to confess their mistakes straightforwardly and honestly. How many times Pavlov, in conversations with his collaborators, admitted: "To err is not shameful. How many times have I been greatly mistaken! I confess it. If you think, you make mistakes. He who doesn't think, he never errs." The main characteristic of scientific thought is love of truth. The investigator learns to love truth in the laboratory where the results of an investigation may be correct or incorrect, where mistakes against the truth of nature are never forgiven. The ability to speak the truth was second nature to Pavlov. In the laboratory Pavlov loved to foretell the expected result of an experiment. With the passion and zeal characteristic of him he drew all his fellow-workers into this matter. A debate arose. Opinions differed. Passion flamed. Something resembling a sweepstake was arranged. But it might happen that the results turned out just opposite to those expected by Pavlov. Then Ivan Petrovich would exclaim: ". . . The devil! Nature is cleverer than we are . . . ." And he would immediately admit, "Of course, the final question belongs to reality. Who knows reality? We do not know all the depths of these processes and their origins." Not only in the laboratory but in every-day life also, Pavlov retained this ability to speak the truth. His was a noble, direct and honest character.

It is sad when the investigator is proud and has too high an opinion of himself. Pavlov taught youth: "Don't allow yourselves to be overcome by pride. On account of pride you will be stubborn where it is necessary to agree. On account of it you will reject useful advice and friendly assistance. Because of it you will lose your sense of objectivity." Modesty should be inherent in the true servant of science. The more experience and knowledge we accumulate the more clearly conscious do we become of how immeasurably great is the unknown in comparison with the scraps of knowledge torn off and perceived. As an example of exceptional modesty Pavlov quoted Newton, who, according to Leibnitz, when approaching the end of his days, said: "It has always seemed to me that I re-

semble a little boy playing with shells at the sea shore, while the entire ocean of knowledge spreads before me untouched." Modesty, the recognition of how little we know as yet, would by no means lead us to a sickly scepticism, to agnosticism. On the contrary, it should inspire us to the performance of new investigations, to rejoice in the victory of knowledge and to find pleasure in the consciousness of how much there is yet to know.

Tormenting and Saving Doubt

Incomplete knowledge gives birth to doubt. Pavlov lived through many periods of doubt during his sixty years of scientific activity. These doubts very rarely had a negative influence on the progress of his scientific work. He did not like to broadcast his doubts. Evidently from pedagogical considerations or in the aim of avoiding the spread of any kind of confusion among the ranks of his young collaborators, he very rarely expressed his doubts before them. But in personal conversations, even more often than in the laboratory, could be heard from his lips: "How pleasant that such a complex system as the higher nervous system of the animals lends itself to physiological analysis. But on the other hand, the thought arises: Everything is clear to us, but perhaps we are fooling ourselves." There were periods when tormenting doubts caused Pavlov much suffering, when the thought of the possible erroneousness of all his investigations arose. Ivan Petrovich survived these dreadful moments alone, passing through them as through a serious illness. He drank in strength and cheer from persistent intense thinking and found consolation in experimental work. In the laboratory he appeared gloomy and worried, but at the same time he listened to the reports of his collaborators on the current work with exceptional attentiveness and considered all details. Days passed and the crisis passed. The solution to the racking doubts was found in new experimental facts, in new achievements.

But there is also another type of doubt which Pavlov called the saving doubt. This kind of doubt is absolutely necessary for fertile scientific thinking. "You must constantly doubt and check up on yourself," he told his pupils. And the doubts must be all the stronger when the first obtained result of an experiment is the one desired. An experiment may be very easily incorrectly interpreted. The experimenter often sees that which he wishes to see, and not that which is present in reality. To avoid making mistakes it is necessary to outdo oneself in inventing numerous variations of the same experiment, to stand the experiment "on its head" in order to verify and control it. It was the strictness with which Pavlov approached the appraisal of factual material which secured the reputation of his laboratory. In cases of incongruity between the experiments performed by others and the data of Pavlov's, he never resorted to verbal criticism but immediately commenced verifying the experiments of others and only after that was done, did he come forward with a refutation of them. Pavlov had a natural aversion and hatred for all unverified and superficial conclusions.

Scientific Fantasy

Without the participation of fantasy, scientific creation is impossible. Simple systematization or accumulation of facts is not sufficient to advance science. A leap in the development of science occurs only when scientific fantasy gives birth to new ideas.

Pavlov's thinking was based on concrete facts—he kept firm hold of the experimental basis. In this regard he was brilliantly able to discipline both his thinking processes and his speech. There was no cleavage between reality and his ideas. But in the process of work, when a scientific theory or a working hypothesis was formulated, Pavlov allowed himself, as he expressed it "to give free rein to

fantasy." He seated himself comfortably in a convenient armchair, adopting a pose which was somewhat unusual to him, when the usual tensity of his muscles and his customary mobility vanished. His expressive and restless hands were folded together and stilled. His words flowed smoothly and calmly. Ivan Petrovich was thinking out loud. A strange feeling pervaded his listeners. It seemed as if the entire creative process was taking place before their eyes, as though under a bell-glass. In these minutes his mind rose to mighty generalizations. For many days after this the laboratory remained in a state of great excitement. The idea thus born was given over for "working out." There arose a harmonious structure of mental conclusions, logically deducted from the critical examination of facts. Those links which were lacking were supplied by new experiments. Aged links, which no longer held, were cast out without any regrets.

Collaborators also were allowed to give free flight to their fancy. Pavlov usually listened to these visionaries with a humorous smile of good will. Inventiveness was encouraged; but groundless, unsubstantiated fantasy was categorically judged. Wordy, artful designs artificially drawn in, in explanation of an experiment, evoked Pavlov's passionate disgust. He stopped listening, or if he found that sort of thing in books he threw the book aside with words of condemnation against the author: "This is false. Instead of concrete material, here is pure speculative philosophy. And I depend on practice. What are the words and thoughts of others to me!"

For the Naturalist the Method is Everything

New methods open new roads for the development of science. Pavlov profoundly understood and valued the significance of method in scientific research. ". . . Science moves by jerks, in dependence upon the successes made by the methods used," he said. "It is as though with every step of the method we rose one step higher and from this higher step were disclosed to us wider horizons containing objects previously invisible to us." The first task which Pavlov set himself when he began the study of digestion was the elaboration of methods adequate for the tasks of the investigation. Looking upon the organism as a complex system in a state of dynamic equilibrium, Pavlov clearly understood that the method of vivisection most profoundly disturbs the entire system as an entity. The results obtained from so-called acute experiments did not reflect the normal relations of the organism to its external surroundings. Under these conditions it was difficult to count upon discovering new laws. And so Pavlov introduced into physiology the method of chronic experiments. For this it was necessary to master and perfect surgical technique, and to introduce aseptic surgery into the field of physiological experiments. Pavlov did both. He became an expert surgeon, and devised new surgical operations. He performed exceedingly difficult and complicated operations on animals. For the first time a surgical section, satisfying all the requirements of the surgery of those times, was opened in a physiological laboratory on a par with the chemical, physical and histological divisions. The operation for the isolation of the stomach suggested by him is insurpassable in conception and delicacy of performance. How much labor and energy was spent on the elaboration of an extirpation method for the solution of the question of cortical localization! For every newly set task there must be found its own adequate method. What a limitless field of investigation of the higher nervous system was opened by the objective method of conditioned reflexes!

"Mine" and "Yours." Wednesdays

Organization of the work is of great significance in scientific investigation. The selection of coworkers, the correct and able distribution of forces are im-

portant. It is well known that Pavlov's laboratories were a center of attraction to persons desiring to join in scientific work. Together with valuable and qualified workers, enthusiasts in their fields, there also came to the laboratory casual people, interested only in solving some private problem or simply desiring to "do" a dissertation. Thanks to Pavlov's gentleness and plain manner of dealing with every one who came to him to work, the doors of his laboratory were always wide open for both young and old scientists. Only in the last few years, because the laboratories were overcrowded, the influx of new collaborators markedly diminished. Pavlov himself selected new workers. He met all newcomers affably and attentively. Often, at the very first meeting Pavlov began telling of the current problems being treated in the laboratory, developed new theories, pointed out the difficulties of investigative work, etc. The conversation bore the nature of a simple, sometimes passionate, but always cordial chat. Pavlov completely forgot that his companion was still not well enough prepared to analyze all the complexities of the facts and suggestions laid before him. Pavlov shared his own thoughts with the newcomer. Under the influence of his warm reception and unusual simplicity, the embarrassment and the timidity of the first meeting disappeared. Pavlov's words already reached the mind of his listener whose thoughts, at first shyly and then more and more freely, began to follow those of Pavlov. At last came the moment when the surroundings were forgotten in the consciousness of the fact that one was listening to the great scientist. The enchanted listener sat motionless with wide-open eyes and eagerly caught at every word. Suddenly Pavlov would cease speaking. A quarter past five! Pavlov would jump up hastily, thrust out his hand in farewell and disappear from the laboratory. For a week such chats were repeated several times. Then the new coworker took his place in the laboratory and began preparatory work. During this period it was as though Pavlov had forgotten about him. His dealings with the new collaborator were restricted to brief comments or directions concerning concrete things directly concerned with the experiment in progress. Essentially Pavlov did not occupy himself with the individual education of each of his collaborators. This was done by the entire laboratory surroundings, the laboratory atmosphere, "in which," according to Pavlov's expression, "every one gives a little of himself but breathes in everything." The newcomer was tutored by the entire group of laboratory workers, by the personal example of Ivan Petrovich, through his boundless devotion to science, his ability to become engrossed in scientific work to the point of self-oblivion. And at the same time the tutoring was accomplished by Pavlov's ability to direct and command the laboratory in the sense of real leadership and making of plans. Ivan Petrovich always stressed that "we are all harnessed to one common work and each moves ahead according to the measure of his own strength and abilities."

The atmosphere of general interestedness, general participation in the work was created naturally and simply. Under the fresh impression of an experiment, excited by new thoughts, Ivan Petrovich went from one room of his laboratory to another and told his collaborators of the new facts just obtained. Since, with the course of time, not only the number of rooms but also the number of workers in the laboratory increased, it became impossible to include all the collaborators in his rounds. Then, upon Pavlov's arrival in the laboratory, all the collaborators would gather together and take part in the conversation.

Beginning with 1924 Pavlov organized "Wednesdays"—conferences including the workers of all the laboratories, which were held on Wednesdays under Pavlov's leadership. "Wednesdays" had a tremendous influence on the progress of

investigations, on the education and unification of all the workers. "Wednesdays" were diligently prepared for not only by all the collaborators who were to report on the course of their work, but also by Pavlov himself. Before the conferences Pavlov carefully verified and thought over all factual material. After a short general introduction, in which Pavlov pointed out the relation of the particular investigations to the general problem with which the laboratory was occupied, the collaborators reporting summarized their experiments. Ivan Petrovich always demanded a brief, clear and concise report. He was interested in all details and himself checked and compared the records of the experiments. In connection with this his unusual memory was always astonishing. Sometimes the collaborator would forget the data from his own previous experiments. Then Pavlov would remind him. Pavlov possessed the remarkable faculty of retaining details from experiments in which several tens of collaborators and more than one hundred dogs were involved. After the report came the process of thinking out loud. Members of the audience contributed their comments, asked questions, requested explanations. Differences, heated arguments arose. There was never calmness or complacency during the discussion of scientific questions at these "Wednesdays." The atmosphere was always strained—in it was always felt the reflection of the fight for the power of man to change and influence nature. It was apparent that here a new world of conceptions was forged. At these "Wednesdays" as well as on all other occasions, Pavlov was capable of openly rejoicing about achievements and being infectiously merry. The conclusion of the conference was usually devoted to reading or discussing new articles or books which Pavlov received from all corners of the world and which his collaborators otherwise had difficulty in obtaining. Thus Pavlov led his pupils through a course in contemporary scientific literature in an interesting and imperceptible manner. Of exceptional interest were those "Wednesdays" on which Pavlov read his own articles, which were likewise subjected to discussion and criticism. With a noteworthy lack of pride and the author's self-love he made corrections on the spot if errors contradicting truth were found. Especially memorable is one of these "Wednesdays" at which Pavlov read his paper on "Conditioned Reflexes" written for the Medical Encyclopedia. This occurred on the eve of his eighty-fifth birthday. During the year Pavlov had been ill several times, and therefore some of his fellow-workers thought that age had put its stamp on his clear mind. There were even some "objective" proofs of this! For instance, Pavlov, for the first time in his life, got himself a note-book, but he used it very rarely, since he always forgot to make notes in it!

Pavlov said beforehand that he would read his recently concluded article "Conditioned Reflexes" the next "Wednesday." Always in such cases there was much excitement in the laboratory. All eagerly waited for Wednesday. At 10:15 Pavlov was already seated in his usual place at the table. Around him were about sixty students and co-workers. To begin with, Pavlov "lit into" the Encyclopedia which, in his opinion, only serves lazy people, and then becoming reconciled he stated—"But by the way, various sorts of people will read it, both clever ones and foolish ones, both those informed about questions regarding the nervous system and those not so informed. And I planned so that every one should gain some profit from reading this article. This explains the simplification, or rather, elementary exposition found in some parts of the article." After this short preface he began to read.

As everything that was written by Pavlov's pen, this article was the fruit of serious and prolonged work. But this

was not a simple exposition of the teaching of conditioned reflexes. All the latest achievements of the laboratories and clinics were organically knit into the article. The question of confluence of physiological phenomena with the experiences of the subjective world is brilliantly revealed by Pavlov, the fundamental laws of the higher nervous activity are described so that every layman can understand them. All the exceedingly vast and complicated material is presented in a clear concise form. Evidently, while writing the article, Pavlov especially kept in mind the reader of an encyclopedia. The reading was concluded. An unusual silence prevailed in the auditorium. Strong emotional excitation was felt by all—the agitating emotion that comes from awareness of thoughts whose exceeding greatness and profundity are not quite realized yet—the triumph of a human mind which does not lend itself to the destroying influence of time.

The prolonged silence somewhat perplexed Pavlov at first, and then he angrily said: "I purposely read this article for you to criticize it, and you keep silent!" He brought his thought to a public court made up of his collaborators. But the "court" was held neither on that day nor later. It was too much for the audience to "pick up" all that which they had just heard. After that, for a long time it was said that Pavlov had given himself the best gift for his eighty-fifth birthday.

His fellow-workers were given much pleasure when Pavlov, in the second half of a "Wednesday," would suddenly become animated and with enthusiasm begin to relate his recollections of the days of his youth, of meetings with people, of past events in which he had participated. He talked in a masterfully expressive way and had a completely original style of speech.

The "Wednesday" program included a ritual for checking up on the time. In exactness and accuracy Pavlov was insurpassable. I believe he can only be compared with Kant, according to whose movements the inhabitants of Königsberg set their clocks. One minute to twelve o'clock the meeting was interrupted and Ivan Petrovich put his watch on the table, the collaborators doing likewise. The seconds were counted in expectation of the Leningrad mid-day signal—a cannon shot. Of course not all the watches kept perfect time—some watches were slightly ahead, others slow and that caused a perfectly natural variance in forecasts as to when the cannon would be let off. Even disputes would arise in the prevailing silence. Pavlov would stubbornly trust only his own watch and keep quiet. The shot! The triumphant voice of Pavlov rings out—"Splendid! It's absolutely exact!" When the cannon was abolished and the correct time announced by radio, a loud-speaker was placed in the auditorium and the ritual retained all its solemn significance.

In the constant mental intercourse it was really impossible to tell what belonged to one and what to another, what was "mine" and what was "yours." In his preface to "Conditioned Reflexes: an Investigation of the Physiological Activity of the Cerebral Cortex," Pavlov gave an excellent appraisal of this method of collective creative work.

"I have to express my warmest thanks to all my fellow-workers who joined their labor with mine in our common task. If I instigated, directed and correlated all our labor, I was myself continually influenced by the vigilance and resourcefulness of my co-workers."

The Teacher

Pavlov's importance and influence as a teacher was tremendous. He had a school unlimited by walls, and a countless number of students. Since 1876,

from the time he was assistant to Ustimovich in the Veterinary Institute, Pavlov took the official title of teacher. Until 1924—when he left the Military Medical Academy—many members of the younger generations passed through his hands. His lectures left their indelible mark. The students clearly felt that his lectures were not only an exposition of physiological knowledge but that at these lectures, in experiments on the laws controlling the activity of the organism which were performed before their eyes, the entire process of scientific work from method to scientific thinking was disclosed and demonstrated. This always made an unforgettable impression, especially in combination with Pavlov's simplicity of exposition and clarity of thought, with his cordial, friendly attitude to youth. Many young doctors were schooled in his laboratory. A comrade at work, Pavlov knew how to combine a loving simple attitude with his high scientific authority. Recalling the years 1886–87, the period of his work under the direction of Pavlov, N. J. Chistovich wrote: " . . . I think that each of us feels a lively gratitude to our teacher not only for his talented leadership, but, chiefly, for the remarkable example which we saw in him, personally, the example of one wholly devoted to science and living only for science in spite of his exceedingly difficult material conditions—literally poverty."

Other evidence is given by a person who worked in Pavlov's laboratory only one winter (1907-1908). Minkovsky, seventeen years after he last saw Pavlov, characterized the image of his teacher thus: " . . . Intercourse with this fearless fighter, who boldly approaches even the most difficult problem and then never retreats from it until nature gives him an answer to the question he put to her, and who in the midst of his work constantly shares his pulsating scientific thoughts with his collaborators, has become for me the source of my love for experimental work. Faith in it as a most mighty means of natural scientific investigation has never left me since."

Many such testimonies can be cited. Only one thing is without question—that every one who entered Pavlov's laboratory left it sharing a great love for science, preserving in their hearts the image of an ideal truth-seeker.

Pavlov's audience was enormous. He read lectures to doctors, spoke for scientific societies and at congresses. He was listened to not only by the scientists of his own country but by those of the whole world. Among foreign colleagues he was given the title of citizen of the world. The last International Physiological Congress recognized him as the first physiologist of the world. The influence of Pavlov's ideas far transcends the boundaries of physiology and spreads to the various medical disciplines—psychology, biology and other branches of positive scientific knowledge.

Pavlov was known to millions of thinking people in the Soviet Union. His teachings on conditioned reflexes are particularly well known. His name is popular abroad among people standing far from physiology or even biology. As a great naturalist his name will be enrolled in the annals of science, where the name, Ivan Petrovich Pavlov, will stand together with the names of the great, whose works illuminate mankind's road to truth and perfect happiness.

Pavlov taught not only how to work scientifically, but how to live, how to love fatherland and man.

From an immeasurably rich nature, Pavlov, with the help of natural science, conquered all that life offers, all that is beneficial and pleasant. In this lies the true happiness of human existence. In the name of this happiness Pavlov gave his life to science.

WHERE OUR NOTABLES CAME FROM

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Despite much sarcasm expended on "The Brain Trust," every one knows that experts and other leaders play a large rôle in our country. They have done so since colonial days, and leadership is becoming increasingly important with increasing complexity of economic, political and social conditions.

Just as there are many sorts of leaders, so are there several different ways of considering their origins. First let us consider the rank of the various states and sections in the yield of notables. Next let us study the comparative yield of areas which differ with respect to such things as climate, ruggedness and wealth. Third, we shall compare the yield of farm, village and different types of cities. Then is considered evidence as to the types of homes which yielded many or few notables, largely a study of the occupations of the fathers of the notables, but some attention is given to religion and European ancestral origin. Finally, some tentative conclusions are offered.

To be recognized as a notable requires more than brightness, nobility of character or even of social desirability. Many bright people lack the ambition, health, education or opportunity to accomplish enough to win recognition as leaders.

Hence this study is of notables who have been so recognized by competent authorities. Several sizable groups are included: the members of the National Academy of Sciences; the scientists who were starred as especially distinguished, at different periods; the lesser scientists also sketched in Cattell's "American Men of Science"; members of the American Academy of Arts and Letters; painters, sculptors and architects of the National Institute of Arts and Letters; presidents of many leading colleges, superintendents of the school systems of numerous large cities, deans of famous schools of law and education; presidents of the American Society of Civil Engineers; labor leaders in "Who's Who in Labor," farm leaders in *Rus* and the millionaires studied by Sorokin. A special study was made of all persons sketched in "Who's Who in America," with the women considered separately. The details for each of these twenty-four groups can not be given here, of course, but some significant facts and conclusions are of interest.

Production by States and Census Groups of States

The six groups of scientists and the eighteen groups of non-scientific notables studied reveal a peculiar concentration of birthplaces. In proportion to population, New England produced about twice as many as did the Middle Atlantic or North Central States, nearly three times as many as the Pacific States, about six times as many as the South Central States.

The southward decline in the yield of notables prevailed not only among the several census groups of states, but also, with very few exceptions, among the individual states. The chief exception is Massachusetts, which surpassed the more northern New England states. Elsewhere the southward decline prevailed almost invariably for the average rank, although in the yield of some particular sort of notable there are exceptions. For example, among the Pacific States, Washington led for most types; next came Oregon, and last came California, which, however, led in members of the

National Academy of Sciences and artists.

Another generalization as to the regional origin of notables justified by the abundant data here summarized is that states that produce few scientists also produce few artists or administrators, and *vice versa*.

The changes from decade to decade in the yield of ten sorts of comparable notables permit a third significant conclusion as to regional productivity, that there has been a progressive decline, at least since about 1860, in the preeminence of New England in the production of notables in proportion to population and a lesser decline for New York and other seaboard states. In contrast, there has been a relative increase in the North Central States and, to a lesser degree, in the Western States. Systematic changes in productivity indicate that changes within the area are important in determining its rank.

Production by Type of Area

The conspicuous regional differences in the yield of notables may advantageously be considered with our attention focused on contrasts in the environment. First let us consider climate. Ellsworth Huntington's theory that a fairly favorable climate is a prerequisite to a high civilization, and hence to the yield of numerous leaders, is not adequately tested by the data here studied, as all parts of the United States which were well-populated when these notables were born have at least a fairly favorable climate. The southward decline is, however, completely in accord with that theory. It may be partly caused by the selective effects of the winters. The long, cold winters of the more northern states are unfavorable to Negroes and are not at all to the liking of the easy-going type of whites, both of whom are numerous in the South. Consequently, although Missouri and Virginia, for example, contain many superior white people and have yielded many leaders, their contribution to leadership, in proportion to population, is notably reduced by their large population of "easily satisfied" people. Abundant evidence, however, indicates that while climate may help explain the general distribution, it is not paramount. For example, nearby areas with essentially the same climates differ greatly in the yield of notables, *i.e.*, the southeastern and southwestern quarters of both Indiana and Illinois, southern Michigan and northern Indiana, and Rhode Island and Connecticut.

Another often held theory is that "as wealth increases so does yield of leaders." True, many relatively rich areas produced more leaders than did certain poorer ones. Thus in each of the six central states studied in detail, the areas relatively productive of notables have distinct geographic advantages over various other areas which are less productive. But, on the other hand, various rich areas have not been nearly so productive of leaders as some poorer areas.

Satisfactory estimates of the comparative wealth of different areas are not available, partly because there are so many aspects of wealth. Nevertheless, the Census Bureau's estimate of the wealth of the states nearest the birth of the notables studied throws light on this theory. The resulting map of the average wealth per square mile resembles in a general way the map of the yield of notables. But the exceptions clearly suffice to prove that wealth per square mile is not a predominant factor. For instance, the Rocky Mountain States have only about one third as much as the South Central States, but have yielded more than twice as many notables proportionately. When individual states are considered, more striking discrepancies are disclosed. Thus, Louisiana had nearly twice the wealth but only one thirtieth the productivity of Maine, and Rhode Island over twice the wealth of Connecticut but less than half the pro-

ductivity. If instead of the wealth per area, the wealth per capita is considered, even less correlation occurs.

Of the various sorts of wealth, the one most widely thought of as "real wealth," namely mineral wealth, seems indeed to be distinctly unfavorable to the yield of leaders. At any rate, almost none were born in the mining communities of America, except a few in parsonages.

The statement of Frederick J. Turner, the eminent historian, that "It often seems to be largely a matter of topography; the level lands yield leaders as well as crops, while the rugged lands produce few of either," led to a special study of the correlation between topography and yield of leaders. In Ohio the area which yielded fewest notables is, indeed, almost the most rugged, but another area which yielded few is flat and agriculturally highly productive. Moreover, the very hilly section of northern Ohio yielded many. In Indiana, likewise, the most rugged area yielded few notables, but much smooth land did no better, and one of the counties which yielded most is one of the roughest. In Illinois, similarly, a large share of the relatively sterile southern section, containing half of the state's population of 1870, is smoother than much of northern Illinois, the birthplace of many notables. In Wisconsin, the relatively hilly unglaciated section yielded few notables, but smooth areas elsewhere were equally sterile, while other hilly areas were productive. In Kentucky, finally, the most level, fertile part of the state, at the west, yielded almost no notables. Thus it seems evident that topography is not a major influence.

As a final section of this part, let us consider stage of settlement and density of population. It has often been asserted that frontiers can not be expected to produce leaders, as the people are engaged in "hewing homes out of the wilderness." Evidence supporting this theory is the fact that there was, in the Midwest, an increased yield of starred scientists in proportion to population from 1860 to 1870 or 1880, and also that the southern halves of the populations of Michigan and Wisconsin yielded many more notables than the northern, which had not then developed beyond the cruder stages of frontier conditions. Contrary evidence is the declining yield in proportion to population that occurred in the Eastern States, and more recently in various parts of some of the North Central States. These declines almost disprove this theory.

Moreover, although southern New England was the first section to be well-peopled and to pass beyond the agricultural stage, it was in these regards only a little ahead of Pennsylvania, which yielded only one third as many notables, relatively. Likewise, Quebec, the first Canadian province to become populous, ranks lowest in the relative yield of Canadian notables. Similarly, densely settled Rhode Island was far excelled by rural Vermont in the yield of notables.

Yield of City, Town and Country

It has often been asserted that most famous Americans were born on farms. On the other hand, certain studies of small groups of eminent people have revealed that many were born in cities. In order to throw light on this question a "special request" was sent to all persons sketched in one edition of "Who's Who in America" to indicate the type of place in which they were born. Replies from 18,400 persons indicate that approximately equal numbers were born on farms, in villages and towns, in small cities and in large cities or their suburbs.

At the 1870 census, the census nearest to the birth of most of the notables, about one tenth of the people of the United States lived in cities of over 50,000; one ninth in cities of 8,000 to 50,000; one twelfth in small places; and almost seven tenths on farms.

Thus in proportion to population, cities contributed nearly six times as

many notables as did farms; villages nine times as many; and suburbs eleven times as many. This does not prove that early life on a farm was unfavorable to future eminence. Indeed, many famous men who were not born on farms spent part of their early life there and considered the experience helpful. In fact, many such famous men have, on occasion, spoken of having been "reared" on a farm.

Further information was obtained by as detailed a study as possible of the birthplaces of the more eminent scientists, artists, authors and engineers, and also of all types of prominent people born in Indiana and five nearby states.

Of the most eminent group of notables, the largest cities yielded many more than their proportionate numbers, the cities of the northeast and their suburbs yielding more than one fourth of the total and the large cities of the South almost a half of the few who were born in the South. Boston and its suburbs were remarkably productive, while New York and Philadelphia and their suburbs also ranked very high. In the Midwest, however, many of the more eminent notables, as well as the lesser notables, were born in villages and a considerable number on farms. Very few of the prominent women, however, were born on farms.

Of the cities and towns of the Midwest, especial note was made as to the relative contribution of county seats and college towns. The average county seat yielded notables at about three times the rate of the rest of the state, and the smaller county seats yielded more relatively than did the larger ones. Likewise, the fourscore cities and towns of the Midwest which contained colleges yielded an average of four starred scientists each, and many other notables, an average productivity of fully twice that of other cities in these states. Approximately one third of the many starred scientists born in Ohio and Illinois were born in college towns and more than half of those of Kentucky. Although college towns yielded relatively many notables, surprisingly few graduated from the college in their birthplace; indeed many graduated from out-of-state colleges. For example, only six out of forty-seven Hoosier women sketched in "Who's Who" graduated from an Indiana college. Only two fifths of Wisconsin's starred scientists did their college work in Wisconsin, and more than half of Michigan's left Michigan for their college degrees. This suggests that the young people, later to become distinguished, were quick to see imperfections in their local institutions and, desiring a superior training, went elsewhere.

In the Midwest, the largest cities of each state did less well than the smaller, and those which grew most rapidly yielded proportionately fewer than other cities in the same state.

Thus it appears that the parents of notables (as might be expected of alert people anxious to better their conditions and possessed of the requisite boldness, energy and resources to do so) gather in the centers of population, as here there are more opportunities to use their skill. In the Midwest, although in 1870 nearly four fifths of the population was rural, the towns already contained, it appears, a considerable share of the parents of leaders. As opportunities for gaining a livelihood in the towns and cities increased, progressively larger proportions of the most alert, ambitious people moved to the more attractive cities, often the county seats with colleges. But the cities also attracted many manual laborers, so that, in proportion to population, the highly intellectual type commonly forms a smaller percentage, except in choice residential sections and suburbs, than in the smaller county seats. Nevertheless, in the yield of the most outstanding artists, architects, authors and scientists, the large cities led in proportion to population.

Home Environments of Notables

The questionnaire sent to all subjects of sketches in "Who's Who in America" for 1922–1923 included a request for information as to the occupations of their fathers. The 18,400 replies revealed that business men and professional men each fathered slightly more than a third of the American notables born about 1870 (35 and 34 per cent.), and farmers almost one fourth (23.4 per cent.). Skilled laborers, however, fathered only a small share (6 per cent.), and the vast number of unskilled laborers almost none.

In proportion to their numbers in the general population at the 1870 census, professional men fathered more than twice as many notables as business men, nearly twenty times as many as farmers, about forty-five times as many as skilled laborers, and 1,340 as many as unskilled laborers. Farmers, on the other hand, fathered one fourth less than their proportionate share, but did much better than other manual workers, contributing more than twice as many as did skilled and semi-skilled laborers and seventy times as many as the nearly one half of the men of the nation who were classed as unskilled laborers. (Farm laborers were included here.)

Thus, although about 1870, only one unskilled laborer in about 38,000 fathered a son or daughter sufficiently noteworthy to win a place in "Who's Who," one skilled laborer in 1,300 had that distinction, one farmer in 550, one business man in 62, and one professional man in 27. In other words, the yield of these notables by the higher types of artisans was about thirty times as great as by the unskilled laborers, whereas the farmers did seventy times as well as the unskilled laborers, business men six hundred times as well, and professional men nearly 1,400 times as well.

As previous studies by Cattell, E. L. Clarke, C. M. Cox, Havelock Ellis and others had indicated that many notables were sons of professional men, the questionnaire sent to the persons sketched in "Who's Who in America" requested a classification of such fathers. Those whose fathers were clergymen were asked to state the denomination, and for other professional men, the profession. Exactly one ninth of the notables reported their fathers as clergymen, which, when due account is taken of the number of Protestant clergymen in America at that time, means that more than twice as large a percentage of clergymen's sons became such conspicuously valuable members of society as to be sketched in "Who's Who" as was the case with the sons of other professional men combined. Thus Protestant clergymen contributed, in proportion to their numbers, four times as many eminent sons as did business men, thirty-five times as many as did farmers, and 2,400 times as many as did unskilled laborers.

The comparative yields of notables by the leading professions and religious denominations are also of interest. From the available data, it appears that, about 1870, one engineer in 196 fathered a notable, one physician in 129, one Methodist clergyman in 97, one lawyer in 66, one sea-captain or pilot in 47, one Baptist clergyman in 44, one Presbyterian clergyman in 11, one Episcopalian clergyman in 9, one Congregational clergyman in 8, and one Unitarian clergyman in 7.

Thus about six times as large a percentage of the children of Episcopalian, Congregational and Unitarian clergymen later were sketched in "Who's Who" than was true for Baptist clergymen, and twelve times as for Methodist clergymen. The lower rank of these latter denominations is partly explained, however, by the large number of Negro pastors in the Southern (African) divisions of these denominations, and also by the fact that some other divisions of Methodists and Baptists then had relatively low educational requirements for their clergymen.

The relatively low rank of engineers in fathering notables will surprise many

who know how capable the best engineers are, but many persons counted by the census of 1870 as engineers were not highly trained men. Likewise many physicians at that time had no high-school training and only a few weeks in medical school. The better physicians were another sort. (Cattell found that of nearly 900 starred scientists, physicians fathered three fourths as many as did clergymen.)

CONCLUSION

In conclusion, it is therefore apparent that a small portion of the men of 1870 fathered a large share of the present leaders. Most of these fortunate men belonged to the so-called upper classes. However, the several geographic sections of America varied in their yield of notables only roughly in accord with their relative numbers of such classes.

The proper interpretation of this concentration is in dispute. Advocates of the theory that environmental influences dominate assert that the classes that produce most leaders do so because they have the best opportunities for cultural and physical development. They claim that there are many children of unskilled laborers who are as capable as the children of the upper classes, and also point out that the South was economically badly handicapped by the Civil War. On the other hand, advocates of the theory that hereditary influences predominate declare that children of unskilled laborers, when adopted into homes of professional men or otherwise given comparable opportunities, nearly always fail to become leaders. They likewise declare that the superior economic status of the fathers of most leaders is the result of their superior qualities of mental alertness, earnestness, ambition and vitality.

Advocates of the theory that social selection is very important find much support in such data as are here summarized. They point out that the mentally alert people are chiefly found in occupations where their mentality is most advantageous, while the mentally dull are chiefly found in occupations calling for physical strength or routine work. Selection of another type is illustrated by immigrants of exceptional ability. These have come from numerous areas; for example, a very considerable number of eminent Americans are of German descent, especially of the liberals who came over following the revolution of 1848. Scotland, both directly and via north Ireland (the Scotch Irish), also has supplied many ancestors of eminent Americans. But according to much evidence, by far the largest group of American leaders are descendants of emigrants from East Anglia, England, the district which, according to Havelock Ellis ("British Genius"), yielded relatively many eminent British and most of the Puritans of New England, the Quakers and the Cavaliers of Virginia. (Cattell found that most of the scientific leaders of 1903 were at least half Puritan in descent). The westward spread of the descendants of the Puritans out from New England clearly helps explain the geographical contrasts in the yield of notables. Conversely, their partial submergence numerically by less valuable stocks largely produce the decline in the yield of notables in proportion to population in New England and various more western areas.

Finally, areas yield most notables which contain most mentally alert, ambitious, persistent, energetic people possessed of high ideals. Such people seek opportunities to use their abilities; they appreciate congenial associates and therefore congregate in desirable towns and in choice residential districts or suburbs of cities. Since Quakers, Scotch, Germans of 1848 and especially Yankees include many people of this type, many notables were born wherever such stocks formed a relatively large share of the population.

CHIPPEWA INTERPRETATIONS OF NATURAL PHENOMENA

By Sister M. INEZ HILGER, O.S.B.
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THE following notes on the interpretations of natural phenomena by the Chippewa were gathered on the Red Lake Reservation of Minnesota in the summers of 1932 and 1933 and on the Lac Courte Orielle, the Lac du Flambeau and the La Pointe Reservations of Wisconsin and the L'Anse Reservation of Michigan in the summer of 1935.

"No one kept account of years in early days." Months were recorded by moons and were known by natural events which occurred from new moon to new moon. Days were counted by nights.

The sun, when eclipsed, was either dying or dead, or being hid by some one. Men shot arrows toward the sun until it reappeared, believing that thereby bad luck was killed. No explanation was known for eclipses of the moon.

The sun and moon represented persons. The moon at one time was a man who had gone to fetch some water and was taken up into the air. Hence, in the full moon one sees a man with a bucket. Stars were not personified.

Thunder and lightning are caused by Nĕmĭ́kĭg, the thunder bird. Nĕmĭ́kĭg flashes lightning when he looks about him to see in what direction he wishes to fly. Immediately after he has taken a glance, he flaps wings and tail, proceeds on his journey and so causes the thunder. When a thunder-storm rumbles through the skies, an old Chippewa may offer tobacco on the fire, smoke his pipe, step out-of-doors, raise his hands toward heaven, and say to the thunder: "Don't scare the children! Keep quiet! Go back!" The storm invariably passes over. "Not every one can do this effectively; only those who have dreamed of thunder."

The power of the thunder bird is shown in the following story:

> A long time ago before the whites came, an old Indian was hunting beaver. The Indians at this time tempered copper into spearheads. Beaver were speared by means of these copper spearheads. This man had a blanket over his head to see where the beavers were. A bird picked up the old man with the blanket and took him up among the clouds. He was afraid to open his blanket to peek out; when he did, he saw the blue sky. The thunder bird had picked him up. He was gone for four years. When he returned to earth the lightning was so strong near him that he couldn't stay near his own people.

An old theory is that the thunder bird also causes northern lights. Other explanations are that they are light reflected from water or ice or that they are caused by an electric storm raging in the far north, or that winds are "blowing furiously high up in the air." Strong winds or severe storms invariably follow two or three days after the appearance of northern lights.

The rainbow, nâgwâ'âb, is the color of the sleeves of Magĕgĕḱwā, a woman who raises her arms over the sky so that her fingers interlock. The appearance of the rainbow is a sign that the rain has ended and that good weather will follow.

One informant said that one night, when he was a little boy, the sky became red and then white (from a comet). "The stones were red from the reflection. It was night but it seemed like daylight. This thing had a long tail which was lighted!" His mother predicted some catastrophe, and soon there was war between the North and the South. His father went away and did not return for three years.

The sun marked the directions by day; the north star, by night. Chippewa Indians following a trail marked a turn toward the setting sun by fastening to a tree a piece of birch bark containing a + sign. A — sign indicated a turn

toward the rising sun. Sundials were at times used in finding directions. More often, however, they indicated the time of the day.

Sundials, to-day, are used primarily when camping away from home and are still made in the same manner as in the early days. On a clear night a man will stake a stick, about a yard high, and lying flat on the ground move about until the stick and the north star are in line. A second stick of about the same length will then be laid to the south of the first and in line with it and the north star, and be staked about a yard from the first. (An informant on the Lac Courte Orielle Reservation did not stake a second stick but simply drew a straight line north and south through the first stick). In the morning a line is drawn through the base of the south stick at right angles to the line of the two sticks. When the shadow of the south stick falls on the westerly line it is about six o'clock in the morning; when it falls in line with the north stick, it is noonday; when on the easterly line it is nearly six o'clock in the evening. The remaining hours of the day are only approximately read.

The method used by an old Indian at Red Lake varies somewhat from the above. Two sticks are staked as described above. In the morning, a third one is staked to the south and in line with the first two. A semi-circle is then drawn through the third stick, convex to the southward. When the shadow of the third stick falls west and tangent to the circle, it is approximately six in the morning; when it falls in line with the two sticks to the north, it is noonday; when, to the east and tangent to the circle, it is approximately six in the evening.

The old Chippewa, too, have ways of foretelling weather. Rain may be expected when birds abruptly end their songs and leave them unfinished. When small lizards that live in decayed wood whistle notes not unlike those of an ordinary human whistle, heavy rainfall and storm are on their way. The singing of tree toads also predicts rainfall. A rainbow in the west predicts more rain; in the east, clear weather. A small circle about the moon never fails to forecast bad weather; a large circle indicates warm weather. Northern lights, as noted before, forecast a storm. Some women can predict weather at maple-sugar making time by the way stars and clouds hang in the heavens. Sundogs in the fall predict heavy snowfalls for the winter.

Throwing a rabbit skin into fire will cause a snowstorm or bring a north wind. Any one wishing the wind to blow in a certain direction must shoot arrows in that direction. Swinging one's hand back and forth in the water while rowing to places may produce a storm.

Drowning dogs or cats in Keweenaw Bay invariably brings a storm. The water will not tolerate decayed matter, and hence produces a prevailing wind in any direction until the dead animal has been landed on shore. One day, two men, hoping to have a favorable wind for a fishing expedition, threw a cat into the bay. They were not disappointed; the wind blew favorably for three days. In early June of 1935, an informant accompanied by two men went out to fish. He noticed a bag near one man and said, "What have you there?"

"A cat that I'm going to drown," the other answered.

"Don't put that cat into the bay or you'll have a wind!"

While they were rowing, a storm suddenly came up.

Our informant inquired, "What did you do with that cat?"

"I threw it into the bay."

"Well, there is your storm!"

THE MARY REED LIBRARY OF THE UNIVERSITY OF DENVER
WHERE THE HUNDREDTH MEETING OF THE AMERICAN ASSOCIATION WAS FORMALLY OPENED WITH A RECEPTION.

THE PROGRESS OF SCIENCE

THE HUNDREDTH MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THIRTY-SIX years ago the association held its fiftieth meeting in Denver. The one hundredth meeting, held during the week of June 21, once again brought home to the citizens of Denver the fact that men and women who devote their lives to the pursuit of scientific inquiry are not necessarily dry, self-absorbed and technical. On the contrary, contact with the members of the association showed them to be surprisingly genial, kindly and sympathetic; and in many of them was found a fine flow of humor flavored with a wit which was none the less attractive because it carried with it no sting.

The Denver meeting was particularly notable for two features: first, the Southwestern and Pacific Divisions held joint meetings with the association; and, second, there were an unusual number of social functions and outings for the members and their guests. Dinners, teas, luncheons and excursions gave the visitors ample and pleasant opportunity to meet and mingle with local members, to see and appreciate Denver "from the inside" and to enjoy the mountain scenery of the district.

The meeting was formally opened with a reception on the evening of Monday, June 21, in the spacious Renaissance Room of the Reed Library of the University of Denver. This affair was well attended and was, to a large extent, responsible for the feeling of general good-fellowship which pervaded the group thereafter.

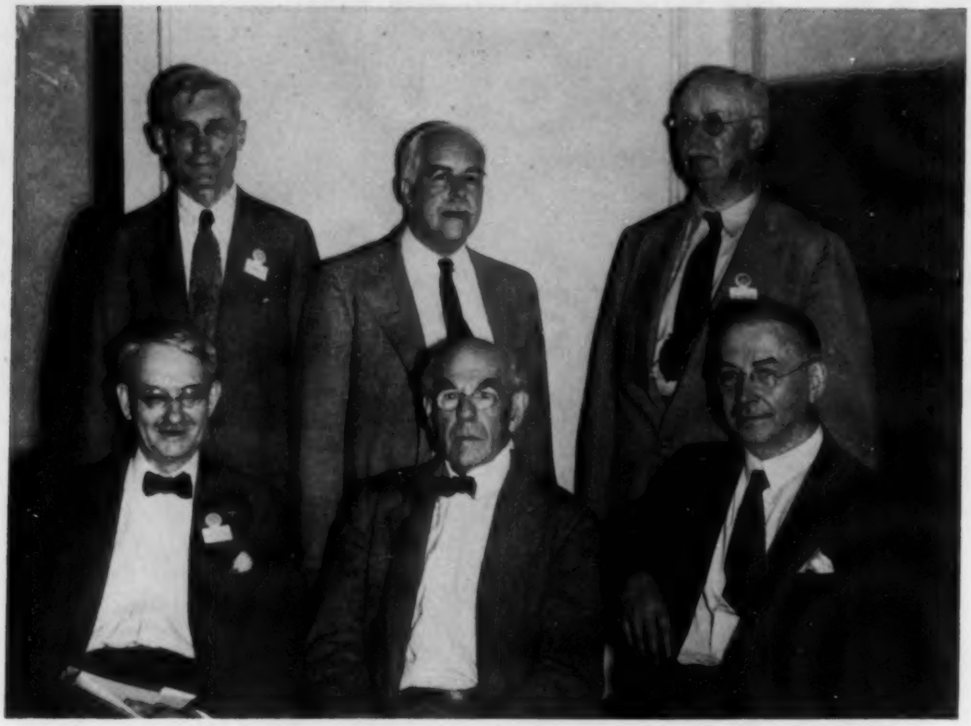
In all, some 590 papers were presented during the sessions of the various sections. It would be fruitless, if not impossible, to give here any adequate discussion or description of these sessions; and, in any event, detailed reports have been made through other media.

As usual, however, the more general or popular sessions attracted the most attention. These comprised three evening lectures by prominent scientists and two "special events" presented at afternoon meetings. The Maiben Lecture, on Wednesday evening, was given by Professor Nevil V. Sidgwick, of Lincoln College, University of Oxford, on the subject "Molecules." Professor Sidgwick first reviewed briefly and concisely some of the more pertinent facts and fancies of the kinetic theory of chemical action and their bearing on the formation and decomposition of molecules. The rest of his time was spent in a discussion of the factors which control and limit the phenomenon of "life"; and, in the end, to the conclusion that this phenomenon must be confined to very few localities in the entire universe. In fact, Dr. Sidgwick stated, it is a safe bet that our earth and probably only two of the other solar planets could possibly sustain life, regardless of the form or type taken by the living organism.

On Thursday evening, the John Wesley Powell Lecture was given by Dr. A. E. Douglass, of the University of Arizona, on the subject of "Tree-rings and Chronology." Dr. Douglass set forth his findings on periods of drought and rainfall as shown by the size and types of tree-rings. After tracing out the method of determination of chronology and local history from the appearance of logs and timbers used in old buildings of the Southwest, Dr. Douglass attempted to tie up his deductions with sun-spot cycles as a means of accounting for the apparent periodicity of the drought cycles.

A feature not listed on the program followed this lecture—a showing of some truly beautiful colored (kodachrome) moving pictures of the growth of crystals under the microscope. Since these pictures were taken in polarized light, the crystal growth was attended by astounding and yet pleasing color changes.

Dr. A. J. Carlson and Dr. Walter Bartky, of the University of Chicago, put on a demonstration of the methods being utilized by that institution for making



MEMBERS OF THE EXECUTIVE COMMITTEE OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

FRONT ROW, LEFT TO RIGHT: E. G. CONKLIN, J. MCKEEN CATTELL, F. R. MOULTON; BACK ROW, LEFT TO RIGHT: R. T. CHAMBERLIN, G. N. LEWIS, OTIS T. CALDWELL.

science not only popular but convincing to the younger generation. Dr. Carlson showed two films (movies), the first entitled "Body Defenses against Diseases," and the second "The Heart and Circulation of the Blood." These films were prepared and are being used for freshman instruction. They combined most ingeniously photomicrography, animated drawings and sound effects to give a vivid and forceful presentation of their subjects. Dr. Bartky's film was entitled "Exploring the Universe." It depended almost entirely on mechanical devices to show the apparent and real motions of the stars and to compress into a few mundane moments the celestial events of many millions of years.

On Thursday afternoon, Chancellor David Shaw Duncan, of the University of Denver, presided over a symposium on the "Scientific Aspects of the Control of Drifting Soils," a subject of immediate and most practical importance to the nation in general and to the inhabitants of this region in particular.

To one who had the good fortune to meet and talk with many of the prominent members during the week of the meeting and who attended several of the technical and popular sessions, it was evident that the aims and purposes of the association were adequately and pleasantly fulfilled at this meeting. As a means of bringing together the best scientific minds of the country, for formal and informal discussion of those particular and general subjects which concern us all; to break down the barriers of specialization and to promote the integration of our hard-won knowledge of this quaint world in which we find ourselves; to help, in however faltering and fitful a way, to a solution of the problems which puzzle us and to aid in the alleviation of the ills and pains that beset us—these objectives were brilliantly attained.

T. P. CAMPBELL

THE AWARD OF THE FRANKLIN INSTITUTE MEDALS TO DRS. MILLIKAN AND DEBYE

In recognition of their efforts "to advance the knowledge of physical science and its applications" the Franklin Medal and Certificate of Honorary Membership was awarded this year to Dr. Robert Andrews Millikan, director of the Norman Bridge Laboratory of Physics, California Institute of Technology, Pasadena, and to Dr. Peter Joseph Wilhelm Debye, director of the Kaiser Wilhelm Institute of Physics, Berlin, Germany, by the Franklin Institute of the State of Pennsylvania.

The Franklin Medal is awarded annually from the Franklin Medal Fund, founded in 1914 by Samuel Insull, Esq., "to those workers in physical science or technology, without regard to country, whose efforts, in the opinion of the Institute, acting through its Committee on Science and the Arts, have done most to advance a knowledge of physical science or its applications."

Dr. Millikan received the medal "In recognition of his isolation and measurement of the fundamental unit of electricity, the electron; the photo-electric determination of the fundamental constant of radiation, Planck's constant; the extension of the ultra-violet spectrum by two octaves to join the spectrum of soft x-rays; and the study of the nature and the properties of a very penetrating radiation of cosmic origin."

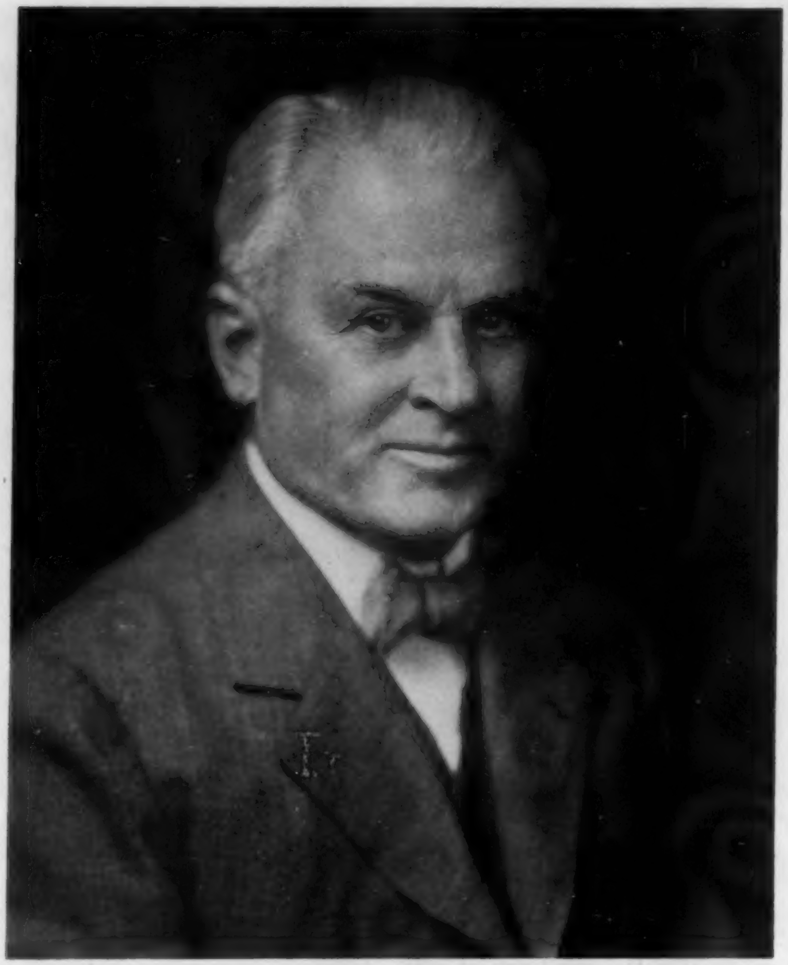
Because of his six weeks' lecture tour in Europe, including the delivery of the Joly lectures in Dublin, from May 1 to 12, inclusive, and his lectures in Scandinavian countries under the auspices of the American-Scandinavian Foundation, Dr. Millikan was not able to receive the award until after his return from Europe on June 25.

Dr. Debye received the medal "In recognition of his fundamental conception and masterly development of the theory that the molecules of many substances possess permanent dipole moments—a theory of great value in stimulating a vast amount of fruitful research on the electrical properties of insulators; his extension and generalization of Einstein's theory of the specific heats of solids; and his work, in collaboration with Huckel, on a theory of the thermodynamic properties of electrolytic solutions —work upon which the whole modern theory of electrolytes is based."

Since Dr. Debye is a Dutch citizen, the medal and certificate were received for him by Count van Rechteren Limpurg, chargé d'affaires of the Netherlands, Washington, D. C.

Dr. Charles P. Smyth, of Princeton University, read Dr. Debye's paper on "Structure in Electrolytic Solutions," which is a brief presentation of the foundations of the classical theory of solutions as laid by Van't Hoff, Arrhenius and Ostwald. For many years no success was reached in dealing with strong electrolytes. This led up to the more modern theories of solutions. Ghosh started from the idea that in a solution of sodium chloride the ions acted so strongly on each other that even in solution an arrangement of sodium and chlorine ions was established as in the solid crystals. Debye, however, considered it impossible that the tendency to produce such an arrangement could be strong enough to bring the lattice-order into real existence. To describe the significant properties of the arrangements of ions in a solution Debye introduced the idea of the ionic cloud.

Debye states: "If one considers an electrolytic solution, for example, a solution of sodium chloride, from the outside, so to speak, then in a specially fixed element of volume in a time-average, just as many positive sodium as negative chlorine ions will be found. Quite different is the picture when the observer is thought of as fixed to one of the sodium ions so that he follows all its movements

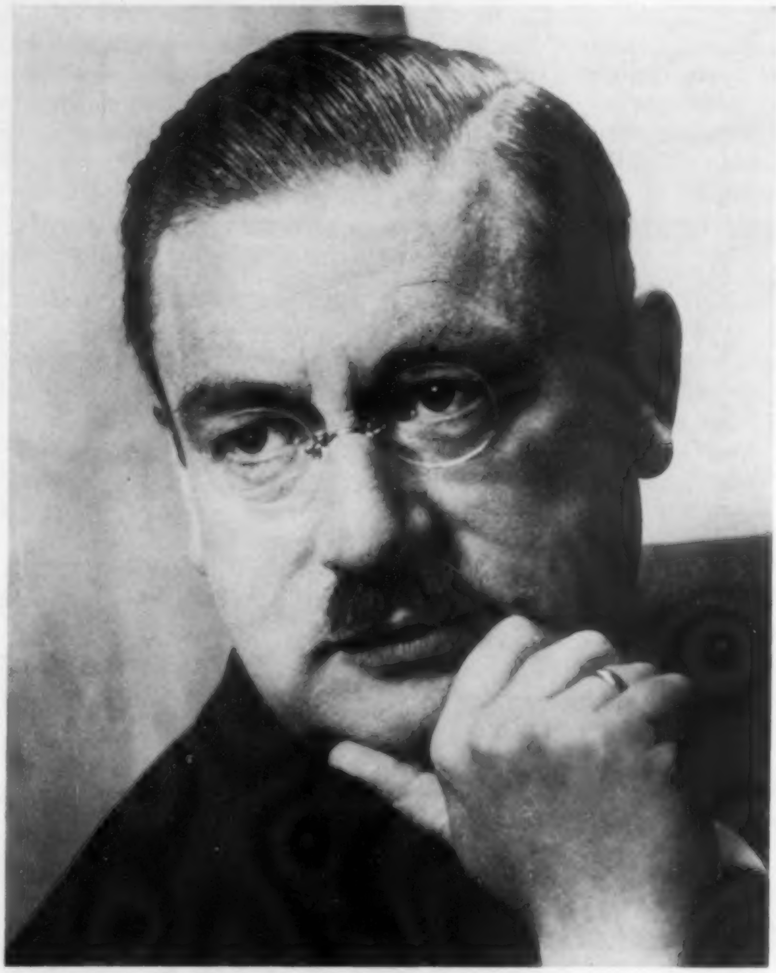


DR. ROBERT A. MILLIKAN

and observes his surroundings from this moving point. Then he will find that chlorine ions are favored, especially at shorter distances, and their number in the time-average exceeds that of sodium ions. We can thus speak of a cloud of electric charge, from which every point has in time average a particular charge density of opposite sign throughout to that of the central ion, but less dense the further the point under consideration is from the center. This is the structure which must take the place of the crystalline structure pictured by Ghosh."

Among other presentations were five awards of the Elliott Cresson Medal. This was founded in 1848 by Mr. Cresson, of Philadelphia, Pa., a philanthropist and successful merchant, who lived from 1796 to 1854. The medal is awarded "for discovery or original research, adding to the sum of human knowledge, irrespective of commercial value; leading and practical utilizations of discovery; and invention, methods of products embodying substantial elements of leadership in their respective classes, or usual skill or perfection in workmanship." The recipients were:

Dr. Carl D. Anderson, California Institute of Technology, Pasadena, "In consideration of his discovery of the positron."



DR. PETER JOSEPH WILHELM DEBYE

Dr. William Bowie, U. S. Coast and Geodetic Survey (retired), Washington, D. C., "In consideration of his contributions to the science of geodesy, particularly with reference to the theory of isostasy, the applications of which he has extended to problems in general geophysics and geology."

Mr. Jacques Edwin Brandenberger, Neuilly-sur-Seine, France, "In consideration of his invention and development of the process of manufacture of continuous transparent sheets of regenerated cellulose which have found a widespread use in industry."

Dr. William Francis Giauque, University of California, Berkeley, "In consideration of his outstanding contributions made to our scientific knowledge in the attainment of temperatures approaching within one fourth of one degree of the absolute zero and of his systematic observance and investigation of various substances at these low temperatures," and

Dr. Ernest O. Lawrence, director of the Radiation Laboratory, University of California, Berkeley, "In consideration of his development of the cyclotron, an apparatus for accelerating ions, which embodies a high degree of technical skill and is of material use in extending the knowledge of nuclear physics."

On the evening of the same day a subscription dinner was given in Franklin Hall of the institute, with Philip C. Staples, president of the institute, presiding. The medalists were introduced, and Count van Rechteren Limpurg, representing Dr. Debye, spoke in appreciation

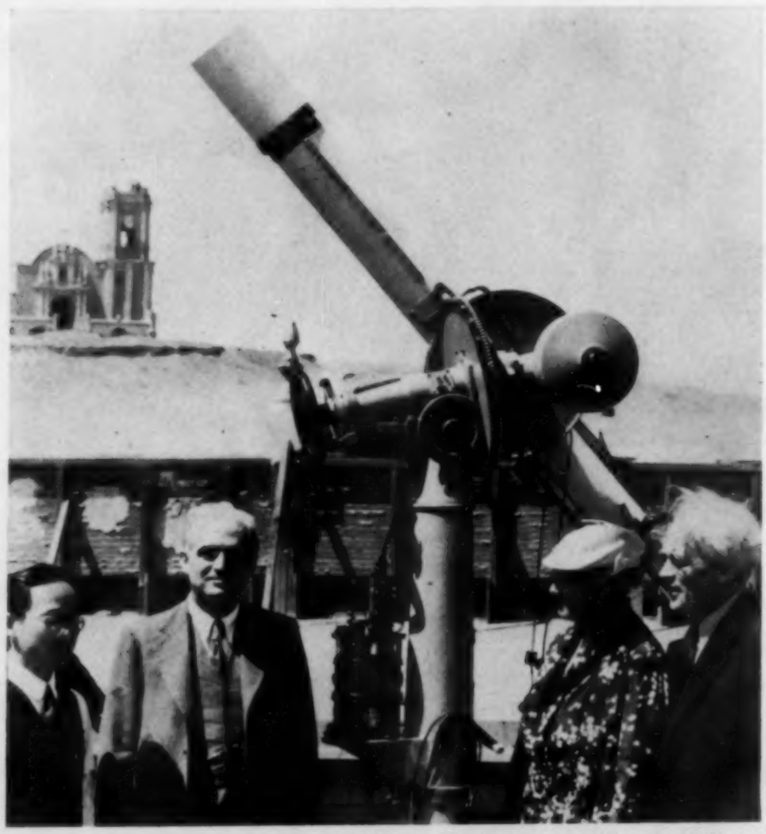
of the honor conferred upon his countryman.

Guy Marriner, associate director in charge of music at the institute, discussed Benjamin Franklin, the musician, and illustrated his talk on the pianoforte and glassychord. There was also a demonstration of a new musical instrument, the oscillion, designed and played by Dr. W. E. Danforth, Bartol Research Foundation of The Franklin Institute.

A. B. H.

THE HAYDEN PLANETARIUM-GRACE PERUVIAN ECLIPSE EXPEDITION

The recent total eclipse of the sun began at sunrise on June 9 on the Pacific Ocean near Australia and, crossing the date line once and the equator twice in its course, ended on the coast of South America at sunset on June 8. It was observed in its early path from a "desert island" by the expedition of the National Geographic Society and the United States Navy; its final darkness fell on the cameras of the Hayden Planetarium-Grace Expedition in Peru, directed by Dr. Clyde Fisher, head of the Planetarium.



Hayden Planetarium-Grace Eclipse Expedition.

IN THE ECLIPSE CAMP NEAR TRUJILLO.

LEFT TO RIGHT: DR. YAMAMOTO, FAMOUS JAPANESE ASTRONOMER, DR. GODOFREDO GARCIA, CHIEF OF PERUVIAN ASTRONOMICAL COMMISSION, MRS. ISABEL LEWIS, OF THE U. S. NAVAL OBSERVATORY, AND DR. CLYDE FISHER.

The South American expedition operated in five sections, partly for variety of observation and partly for certainty of observation in the event of local clouds. The eclipse was fortunately visible to every division and records were brought back from stations ranging from sea level to the sub-stratosphere.

The photographic equipment of past expeditions was augmented by motion picture cameras with color films. One of these was carried to 25,000 feet of altitude in the Panagra plane "Santa Silvia," where three operators, including Major Albert W. Stevens, made pictures as they breathed through oxygen tubes. With their cameras blanketed against the cold, they obtained large images of the corona with exposures of a twentieth of a second, as well as pictures of the receding shadows on the clouds and Andes Mountains.

Over two miles above sea level, the members of the Cerro de Pasco division made photographs of the corona, sketches of the prominences and the frantic beginnings of four paintings depicting phases of the eclipse.

In the yard of an ancient adobe church at 12,000 feet was a station where the Columbia Broadcasting System amid much clamor from the natives described the event to listeners in the United States.

After eight successive days of cloudiness during rehearsals at a 10,000 foot station, another division carrying huge cameras moved just before the eclipse to a pre-Inca fort, named Huecor, at 2,400 feet.

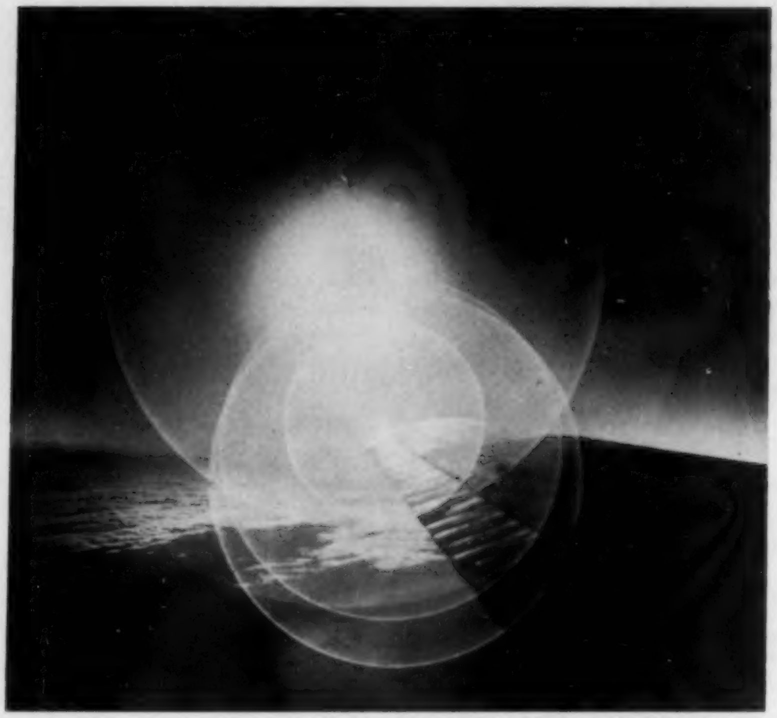
At sea level, Dr. Clyde Fisher's Huanchaco division, due to its extreme western position, enjoyed the highest sun, $9\frac{1}{2}°$ above the horizon at mid-totality.

The "first contact" of the moon with the sun occurred at 4:15 P.M. At 5:18 came the "second contact" or the beginning of totality, which lasted two minutes and thirty-three seconds, the longest eclipse in over a millennium. Just at "second contact" appeared a "diamond-ring" effect and the corona. The famous "diamond-ring" is formed by the thin

Hayden Planetarium-Grace Eclipse Expedition.

ECLIPSE OBSERVERS AT CERRO DE PASCO.

FROM LEFT TO RIGHT: D. OWEN STEPHENS, ASTRONOMICAL PAINTER, WILLIAM H. BARTON, JR., MRS. BARTON, MISS DOROTHY A. BENNETT AND CHARLES H. COLES.



Hayden Planetarium-Grace Eclipse Expedition.

A FREAK PHOTOGRAPH OF THE ECLIPSE

THIS UNIQUE UNRETOUCHED PHOTOGRAPH, ONE OF A SERIES MADE BY THE HAYDEN PLANETARIUM-GRACE ECLIPSE EXPEDITION IS ONE OF THE OCCASIONAL FREAKS THAT OCCUR IN PHOTOGRAPHY. IT WAS MADE LOOKING NEARLY DIRECTLY WEST OVER THE LEFT WING OF A PAN-AMERICAN GRACE AIRWAYS AIRPLANE OVER THE COAST OF PERU AT AN ELEVATION OF 25,000 FEET, A SECOND OR TWO BEFORE TOTALITY OF THE SOLAR ECLIPSE OF JUNE 8. ALTHOUGH ONLY A POINT OF DIRECT SUNLIGHT WAS STILL VISIBLE, THIS WAS SUFFICIENT TO ENTER THE CAMERA LENS AND CAUSE THE CENTRAL SPOT OF LIGHT WHICH APPEARS IN THE PRINT TO BE THE COMPLETE DISC OF THE SUN, AND TO FORM IN ADDITION (THROUGH REFLECTION BETWEEN THE SEVERAL SURFACES OF THE CAMERA LENS) A SERIES OF CIRCULAR RINGS ON THE NEGATIVE. IN THE FOREGROUND, 22,000 FEET BELOW, THE LAST BIT OF SUNLIGHT IS SHINING ON A CLOUD BANK 3,000 FEET OVER THE OCEAN. THE MANY OTHER PICTURES OF THE EXPEDITION, THOUGH LESS SPECTACULAR THAN THIS, HAVE MORE SCIENTIFIC VALUE. (PHOTOGRAPHED BY MAJOR ALBERT W. STEVENS.)

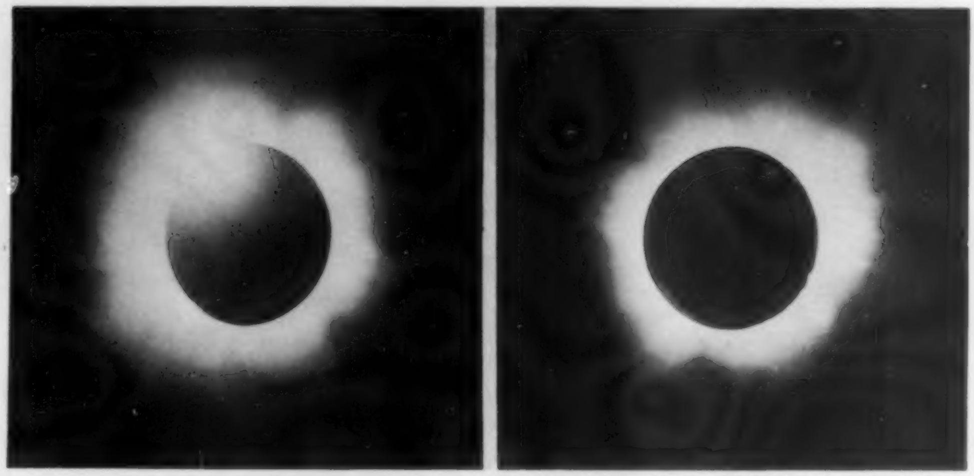
inner corona around the dark shadow of the moon and the last rays of the sun on one side shining through some valley or between some irregularities on the surface of the moon. The large solitaire of the "ring" was seen to break fleetingly into two small jewels before giving place to the outer corona.

The rays and streamers of the outer corona, extending for nearly two solar diameters into space, were of approximately the same length in all radii of the sun. This was due to the high incidence of sun-spots, three large groups having been observed on the day of the eclipse. During a minimum sun-spot period, the polar streamers are short, while the equatorial rays are very long.

Just at "second contact," the ridges of the prominences appeared in six different places along the moon's edge. Two grew and changed, rising and weaving as they swirled up to a full tenth of the sun's diameter.

Another "diamond-ring" appeared at the end of totality. Casting strange shadows, the partially eclipsed sun set in the ocean, the tips of the crescent pointing upward.

C. P. K.



Hayden Planetarium-Grace Eclipse Expedition.

STAGES OF THE ECLIPSE

LEFT, A "DIAMOND-RING" PHOTOGRAPH OF THE ECLIPSE OF JUNE 8, MADE JUST TEN SECONDS BEFORE THE MOON COMPLETELY COVERED THE SUN. RIGHT, TOTAL ECLIPSE OF THE SUN OF JUNE 8. THE CORONA IN THE "DIAMOND-RING" APPEARS UNUSUALLY WIDE IN SPITE OF SHORT EXPOSURE AND IS DUE TO THE FACT THAT THE PHOTOGRAPH WAS TAKEN IN RAREFIED ATMOSPHERE SOME 15,000 FEET ABOVE SEA LEVEL. (PHOTOGRAPHED BY PROFESSOR WILLIAM H. BARTON, JR.)

WOODS HOLE CONFERENCE ON THE PROBLEMS OF AGING

THE Union of American Biological Societies is interested in the promotion of activities which will tend to focus the somewhat divergent interest of its member societies on specific problems of fundamental importance. The common feature of all member societies is that they are concerned in the investigation of living things. All these have a cycle of youth, maturity and old age. The problems of growth, the upswing of the curve of vital processes, are being energetically attacked with adequate financial support. Those of aging, the downswing of the curve resulting inevitably in death, are on the contrary shamefully neglected. We are all agreed that the problem of aging demands attention, and it does so more insistently as the average age of the population increases with improved food, living conditions and medical care. There is, however, little agreement as to the particular aspects of the problem which are of strategic importance and for which we have methods likely to yield worth-while results. Moreover, the data already available have not been collected and pieced together in such a way as to give a clear view in outline of the problem in its entirety. A survey, preliminary to the organization of research on a large scale, is therefore indicated.

The union is not at present concerned with economic and social consequences of aging, important though they undoubtedly are, but with the biological and medical aspects of the processes of aging. Since, as we have intimated, aging is a feature in the life of all organisms, this information must be gathered broadly from many forms in addition to man. Consequently, the Union, in fulfilment of its integrative duties in the biological sciences, sponsored a conference on the problem viewed from these angles held at the Cape Codder Hotel, Woods Hole, Mass., on June 25 and 26. The Divisions of Medical Sciences, Biology and Agriculture and Anthropology and Psychology of the National Research Council cooperated. The expense of the conference was defrayed by a grant from the Josiah Macy, Jr., Foundation. Those attending the conference were: A. J. Carlson,

MEMBERS OF THE WOODS HOLE CONFERENCE ON AGING

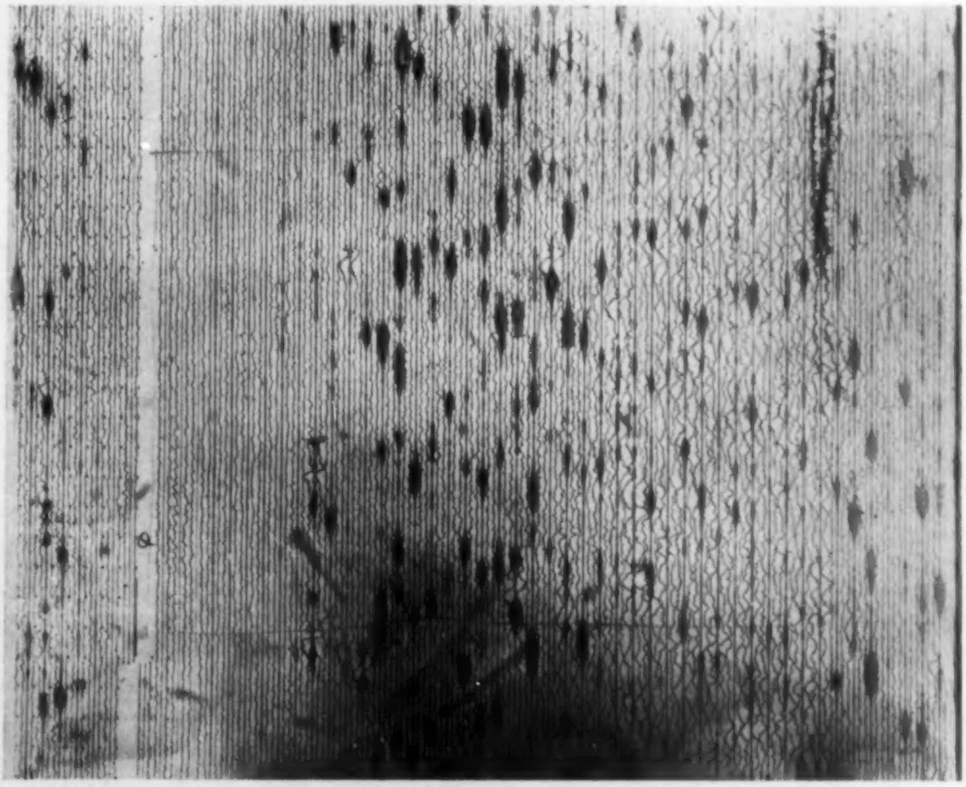
WHICH CONVENED AT THE CAPE CODDER HOTEL ON JUNE 25 AND 26, UNDER THE CHAIRMANSHIP OF DR. COWDRY. STANDING, LEFT TO RIGHT: DR. JEAN OLIVER, (PATHOLOGY) STANFORD UNIVERSITY MEDICAL SCHOOL; DR. WALTER R. MILES, (PSYCHOLOGY) YALE UNIVERSITY; DR. C. M. MCCAY, (ANIMAL HUSBANDRY) CORNELL UNIVERSITY; DR. A. J. CARLSON, (PHYSIOLOGY) UNIVERSITY OF CHICAGO; DR. F. FREMONT-SMITH, MEDICAL DIRECTOR, JOSIAH, MACY, JR., FOUNDATION; DR. EARL THERON ENGLE, COLLEGE OF PHYSICIANS AND SURGEONS; DR. LAWRENCE K. FRANK, ASSISTANT TO THE PRESIDENT, JOSIAH MACY, JR., FOUNDATION; DR. JONAS S. FRIEDENWALD, JOHNS HOPKINS MEDICAL SCHOOL; DR. CLARK WISSLER, (ANTHROPOLOGY) AMERICAN MUSEUM OF NATURAL HISTORY; DR. T. WINGATE TODD, (ANATOMY) WESTERN RESERVE UNIVERSITY SCHOOL OF MEDICINE; DR. WM. DE B. MACNIDER, (PHARMACOLOGY) UNIVERSITY OF NORTH CAROLINA; DR. ALFRED E. COHN, (INTERNAL MEDICINE) ROCKEFELLER INSTITUTE; DR. ALFRED FRIEDLANDER, DEAN OF THE SCHOOL OF MEDICINE, UNIVERSITY OF CINCINNATI; DR. LOUIS I. DUBLIN, (STATISTICS) METROPOLITAN LIFE INSURANCE COMPANY. SITTING, LEFT TO RIGHT: DR. H. S. JENNINGS, (ZOOLOGY) THE JOHNS HOPKINS UNIVERSITY; DR. W. S. HUNTER, (GENETIC PSYCHOLOGY) CLARK UNIVERSITY; DR. ELMER D. MERRILL, (BOTANY) HARVARD UNIVERSITY; DR. E. V. COWDRY, (CYTOLOGY) SCHOOL OF MEDICINE, WASHINGTON UNIVERSITY; DR. E. B. KRUMBHAAR, (PATHOLOGY) SCHOOL OF MEDICINE, UNIVERSITY OF PENNSYLVANIA; DR. WILLIAM CROCKER, BOYCE-THOMPSON INSTITUTE FOR PLANT RESEARCH.

Alfred E. Cohn, E. V. Cowdry, William Crocker, Louis I. Dublin, E. T. Engle, Lawrence K. Frank, Jonas S. Friedenwald, Alfred Friedlander, W. S. Hunter, H. S. Jennings, E. B. Krumbhaar, C. M. McCay, Wm. de B. MacNider, E. D. Merrill, Walter R. Miles, Jean Oliver, F. Fremont-Smith, T. Wingate Todd and Clark Wissler. They include representatives of the union, the council, the foundation, contributors to a book on aging being prepared by the foundation and other interested persons.

E. V. COWDRY,
Chairman of the Conference

CEREBRAL STATES DURING SLEEP AS STUDIED BY HUMAN BRAIN POTENTIALS

IF small metal electrodes are fastened to the scalp of a person, connected with a high gain amplifier, and the resulting electrical potentials observed or recorded, it is found that regular rhythmic changes in potential occur of five to several hundred microvolts amplitude and one to .03 seconds duration. They come from the cerebral cortex and give us an objective method of investigating activity of the brain. The most interesting and best known of these rhythms has a frequency of about 10 per second and is called the alpha rhythm. It is affected by vision, emotional states, sleep and many other conditions. It is most apparent in some



BRAIN WAVES DURING SLEEP

SECTION OF AN EIGHT-HOUR RECORD DURING A NIGHT'S SLEEP. THREE PENS RECORD POTENTIALS FROM THREE DIFFERENT PARTS OF THE HEAD, ONE PEN FROM AN AMPLIFIER TUNED TO 14 PER SEC. RHYTHM, SHOWING VERY CLEARLY THE "SPINDLES." FROM LEFT TO RIGHT THE STATES PASSED THROUGH ARE C, B, C, D AND C. THE MARKED HIGH FREQUENCY POTENTIALS IN THE UPPER RIGHT-HAND CORNER ARE DUE TO MOVEMENT OF THE SLEEPER. DOTS AT LEFT-HAND EDGE OF FIGURE MARK SECONDS.

persons lying quietly with eyes closed and immediately disappears if the eyes are opened to view an object.

A series of over 200 records with 70 individuals of all ages has demonstrated that these potentials of the brain recorded from similar positions on the scalp of normal persons differ greatly in pattern. Two types of individuals, with every possible intergrade, can be distinguished; at one extreme the type with almost continuous pure alpha (ten a second) rhythm; at the other the type with practically no alpha rhythm but with less regular higher frequency, so-called beta potentials. One interesting case was observed of no alpha rhythm except for a few seconds after the eyes had been closed. This appeared whether the room had previously been lighted or was completely dark.

During sleep, the potential patterns change completely. They are so characteristic that they may be used as a criterion of states or depth of sleep. In a person showing continuous alpha rhythm we may distinguish the following states, described in the order in which they appear as a person sleeps: (A) *Interrupted alpha, i.e.,* more and more marked interruption of the alpha rhythm; (B) *Low voltage,* complete disappearance of the alpha activity with only low voltage changes of potential; (C) *Spindles,* the record slightly irregular, with short 14 per second rhythms or "spindles" every few seconds; (D) *Spindles plus random,* random potentials plus short bursts of 14 per second rhythm; (E) *Random,* the spindles become inconspicuous, but the large random potentials persist and come from all parts of the head.

The non-alpha type of person passes into the same states of sleep as the alpha type, but it is difficult to distinguish states A and B. State B is characterized by less high frequency potentials.

During a night's sleep or an afternoon nap, there is a continual shift of the person from one state to another. The changes are usually sudden, but may be gradual, especially from C to D and from D to E. There is no evidence of a continuous curve of sleep, although it is more difficult to wake a person in states D and E. The changes in state of sleep may be plotted against time and give a sleep record or hypnogram.

Movements may occur without any change in state of sleep, and a change in state of sleep may occur without movement, but occasionally the two are connected. After a movement the state usually changes upward and, when in the B state, alpha rhythm for a few seconds (A state) almost always occurs after a movement.

Stimuli or disturbances may shift the state of sleep suddenly. The shift is always upward, from one state to the next above, or one or two states may be skipped. Lack of a continued stimulus to which a sleeper is accustomed may act as a disturbance. Changes in state of sleep have been observed with no detectable external stimuli, but internal changes may be responsible. The ease of changing a state of sleep depends on which state the subject is in, changes appearing less and less frequently as the sleeper approaches the E level. These changes in state as the result of stimuli are frequently but not always accompanied by movement.

Finally, it must be emphasized that changes in pattern of brain activity after a stimulus are not the direct representation in the cortex of impulses from that particular sensory pathway but represent changes in state of cortical activity over wide areas. This is particularly evident in sleep. Thus a sound may result in the appearance of alpha rhythm for a few seconds, but we interpret this as representing a change in level of consciousness rather than a direct effect of the sound stimulus.

Evidence from two sleepers who awoke after dreaming leads us to believe that dreams occur in the B state but are not represented by any peculiar type of potential.

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